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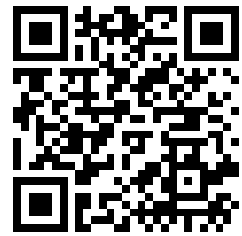

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Army Entrance Regulations:—

R.M. Academy. Admission to, and for First Appointments therefrom to the Royal Artillery and Royal Engineers, during the period of the War. 1915. Provisional. 1*d.* (1*d.*)

R.M. College. Admission to, and for First Appointments therefrom to the Regular Army, during the period of the War. 1915. Provisional. 1*d.* (1*d.*)

Militia and Imperial Yeomanry. Officers of. 1907. 1*d.* (1*d.*)

Special Reserve of Officers, Malta Militia, Bermuda Militia, Channel Islands Militia, and Territorial Force. Officers of the. 1912. 1*d.* (1*d.*)

University Candidates. 1912. 1*d.* (1*d.*)

Military Forces of the Self-governing Dominions and Crown Colonies. Officers of the. 1912. 1*d.* (1*d.*)

Warrant Officers and N.C.O. of the Regular Army. Combatant Commissions as Second Lieutenants. 1914. Provisional. 1*d.* (1*d.*)

See also Commission; Medical Corps; Special Reserve; Territorial Force, Veterinary Corps.

Army List. The Quarterly (*not issued in* October 1914). Each 15*s.* (10*s.* 9*d.*)

Army Pay, Appointment, Promotion, and Non-Effective Pay. Royal Warrant. 1914. 6*d.* (7*d.*)

Army Allowances Regulations. 1914. 6*d.* (6*d.*)

Army Review. Quarterly. July 1911 to October 1914. 1*s.* (Up to July 1914, 1*s.*; Oct. 1914, 11*d.*) (*Publication suspended.*)

Army Service Corps:—

Regimental Standing Orders. 1911. 6*d.* (6*d.*)

Do. Amendments. 1*d.*; A.S.C. Memorandum, No. 25. 1*d.* (1*d.*)

Training. Part I. 1909. (Reprinted, with Amendments, 1915). 9*d.* (9*d.*)

Do. Part II. Supplies. 1909. (Reprinted, 1914, with new Appendix XII.) 1*s.* 3*d.* (1*s.* 1*d.*)

Do. Part III. Transport. 1911. (Reprinted, with Amendments to April 1915). 9*d.* (9*d.*)

Do. Part IV. Mechanical Transport. (*Out of print*)

Do. Amendments, July 1914, to Parts I and III. 3*d.* (3*d.*)

Artificers. Military. Handbook. 10th edition. 1915. 9*d.*

Artillery at the Picardy Manœuvres in 1910. Translated from the French. 2*s.* 6*d.* (2*s.*)

Artillery. Royal:—

Officers' Mess Management. (*See* Ordnance College).

Practice Instructions—

Garrison. Coast Defences. Seawards. 1914-15. 3*d.* (3*d.*)

Garrison. Siege and Movable Armament. 1914. 3*d.* (3*d.*)

Horse, Field, and Heavy. 1914. 6*d.* (5*d.*)

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Artillery. Royal—*continued.*
Standing Orders for—
Brigade of Mounted Artillery. 1*d.* (1*d.*)
Lieutenant-Colonel's Command, R.G.A. (Coast and Siege). 1*d.* (1*d.*)
Training—
Field. 1914. 9*d.* (9*d.*)
Do. Examples of Ranging. To supplement those given in Sec. 227. 2*d.* (2*d.*)
Garrison—
Vol. I. 1914. 6*d.* (6*d.*)
Vol. II. (Siege). 1911. (Reprinted, with Amendments, 1914). 9*d.* (8*d.*)
Vol. III. 1911. (Reprinted, with Amendments, 1914). 1*s.* (11*d.*)

Artillery College. Reports upon the 14th to 18th Senior Classes. Each 1*s.* (9*d.*) (*See also* Ordnance College).

Artillery. Field. The Tactics of. (*Von Schell*). Translated. 1900. 1*s.* (10*d.*)

Artillery Instruments. Handbook of. 1914. 1*s.* 6*d.* (1*s.* 4*d.*)
Do. Amendments. 1*d.* (1*d.*)
Do. Addendum to. 2*d.* (2*d.*)

Artillery Museum in the Rotunda, Woolwich. Official Catalogue. 1906. (*Sold at the Rotunda.* 1*s.* 6*d.*)

Artillery and Rifle Ranges Act, 1885, and Military Lands Acts, 1892 to 1903. Byelaws under :—
Aldeburgh, 1896 ; Ash (Aldershot Camp), 1887 ; Finborough, 1901 ; Hythe, 1894 ; Inchkeith Battery, 1896 ; Kinghorness, 1896 ; Landguard, 1887 ; Lydd—Dungeness, 1895 ; Middlewick, 1890 ; Millbrook, 1888 ; Orchard Portman, 1896 ; Scarborough, 1902 ; Scraps Gate, 1886 ; Shoeburyness, 1895 ; Southwold, 1896 ; Strensall, 1900 ; Wash, 1891 ; Whitehaven Battery (Cumberland), 1896. Each 1*d.* (1*d.*)
Purfleet, 1911. 1*s.* (9*d.*)
Salisbury Plain, 1900. 4*d.* (4*d.*)

Artillery Store Accounts and the Supervision of R.G.A. Sub-Districts. Notes on. 1914. 1*s.* (10*d.*)

Artillery Store Accounts and the Care and Preservation of Equipment of Royal Artillery, Horse, Field, and Heavy Batteries. Notes on. Sept. 1914. 6*d.* (5*d.*)

Barracks. Care of. Instruction in. 1901. 9*d.* (7*d.*)

Bashforth Chronograph. Experiments with, to determine the resistance of the air to the motion of projectiles. Report on. 1870. 1*s.* (9*d.*)

Bayonet Fighting. Instruction with Service Rifle and Bayonet. 1915. 1*d.* (1*d.*)

Bayonet Fighting for Competitions. Instruction in. 1*d.* (1*d.*)

Bermuda Militia Artillery. Regulations. 1914. 9*d.* (7*d.*)

Bicycles. Military. Handbook on. 1911. (Reprinted, with Amendments, 1914). 1*d.* (1*d.*)

British Minor Expeditions, 1746 to 1814. 1884. 2*s.* 6*d.* (1*s.* 11*d.*)

Cadet Units. *See* Territorial Force.

Camel Corps Training. Provisional. 1913. 8*d.* (7*d.*)

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Cape of Good Hope. Reconnaissance Survey of the. 1903-1911 Report on the. 1*s.* 6*d.* (1*s.* 1*d.*)

Cavalerie. Translated from the French of Captain Loir. (*In the press*)

Cavalry of the Line. Peace Organization of the; and Arrangements for Mobilization consequent on the establishment of Cavalry Depôts. (Special A.O., July 19, 1909). 1*d.* (1*d.*)

Cavalry School, Netheravon. Standing Orders. 1911. 2*d.* (2*d.*)

Cavalry Training. 1912. (Reprinted, with Amendments, 1915). 1*s.* (11*d.*)

Ceremonial. 1912. 3*d.* (4*d.*); Provisional Amendments, June 1914. 1*d.* (1*d.*)

Chemistry. Practical. Quantitative and Qualitative. A Course of. 5*s.* (3*s.* 8*d.*)

Chemists of the Research Department. Rules and Regulations. 1*d.* (1*d.*)

Chiropody Manual. 2*d.* (2*d.*)

Civil Employment for Ex-Soldiers. Guide to. 1913. 2*d.* (2*d.*)

Civil Employment Regulations. 1913. 1*d.* (1*d.*)

Civil Power. Duties in aid of the. Special A.O., Dec. 17, 1908. (Amendments to "King's Regulations" and to "Manual of Military Law"). 1*d.* (1*d.*)

Clothing and Necessaries (including Materials). Priced Vocabulary of. 1915. Provisional. 1*s.* (11*d.*)

Clothing Regulations:—

Part I. Regular Forces (excluding the Special Reserve). 1914. 6*d.* (6*d.*)

Part II. Special Reserve. 1914. 3*d.* (3*d.*)

Part III. Mobilization, Field Service, and Demobilization. 1908. 3*d.* (3*d.*); Amendments to Parts I., II., and III. Nov. 1909, April, Oct. 1910, March, April, Sept., Nov. 1911, Feb., May, July, Sept. 1912, April, July 1913. Each 1*d.* (1*d.*)

Colchester Garrison. Standing Orders. 1913. 9*d.* (7*d.*)

Command. Aldershot. Standing Orders. 1914. 2*s.* 3*d.* (1*s.* 9*d.*)

Command. The Art of. By Colonel von Spohn. Translated. 1*d.* (1*d.*)

Command. Western. Standing Orders. Jan. 1910. (Reprinted, with Amendments, 1915). 6*d.* (5*d.*)

Commands, Military, and Staff in the United Kingdom. Reorganization of. (Special A.O., Jan. 6, 1905, with alterations to date. Issued with Special A.O., Nov. 11, 1907). 3*d.* (3*d.*)

Commission in H.M. Regular Army (from 1st April 1912). Short guide to the various ways of obtaining a; &c., &c. April 1912. 2*d.* (2*d.*) (*See also* Army Entrance; Medical Corps; Special Reserve; Territorial Force; Veterinary Corps).

Company Training. Notes on. For the use of the Special Reserve; Territorial Force, and newly raised Units of the Regular Army. Sept. 1914. 1*d.* (1*d.*)

Conveyance of Troops and Issue of Travelling Warrants. Instructions. 1910. 2*d.* (2*d.*)

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Cooking. Military. Manual of. 6*d.* (5*d.*)
Cooking and Dietary. Military. Manual of. Mobilization. 1915. 2*d.* (2*d.*)
Crews of War Department Vessels and Boats at Home Stations. Regulations for the Appointment, Pay, and Promotion of. 1911. 2*d.* (2*d.*)
Cyclist Training. Provisional. 1914. 3*d.* (3*d.*)
Division Orders. Extracts from. 1880. 2*s.* 6*d.* (1*s.* 9*d.*)
Drainage Manual. 1907. For the use of Royal Engineer Officers, and other persons, employed on the Construction and Maintenance of Drainage Works in connection with War Department Buildings in the United Kingdom or in similar climates. (*Reprinting*)
Drawing Plates. Military:—
Attack of Dufor's Countermines or 2nd plate of Mines; Carnot's First System; Detached Forts; Concealed Defences, 1, 2, 3, 4; Printing Plate, A, B, C, &c.; Detail Plate, No. 1; Do. No. 2; Neighbourhood of Woolwich; Village and Surrounding Ground; each 2*d.* (2*d.*)
Attack of Fortress—Preliminary Operations; Do., Distant Attack; Do., Close Attack; Neighbourhood of Metz; each 3*d.* (3*d.*)
Woods and Villages. Six plates. Each 6*d.* (5*d.*)
Neighbourhood of Woolwich. Southern Side. 1*s.* 6*d.* (1*s.* 1*d.*)
Dress Regulations. 1911. 2*s.* 6*d.* (2*s.*); Amendments. March, Aug. 1912. Each 1*d.* (1*d.*); Aug. 1913. 2*d.* (2*d.*)
Drum and Flute Duty for the Infantry, with Instructions for the Training of Drummers and Flautists. 1887. 2*s.* (1*s.* 6*d.*)
Dynamics. Notes on. (*See* Ordnance College).
Egypt. British Force in. Standing Orders. 1912. 1*s.* (10*d.*)
Egypt. Campaign of 1882 in. Military History. With Case of Maps. Condensed Edition. 1908. 3*s.* 6*d.* (2*s.* 8*d.*)
Electrical Communications. Fixed. Instructions as to. 1912. 4*d.* (4*d.*)
Electricity and Magnetism. Text Book for the use of the Cadets at the R.M. Academy. 1911. 2*s.* 6*d.* (2*s.*)
Electricity. Notes on. 1915. 1*s.* (*In the press*)
Electric Light Apparatus. Defence. Instructions for the working of. 1911. 1*d.* (1*d.*)
Electric Lighting. Military. Vol. I. 1*s.* (11*d.*); Vol. II. (Reprinted, with Amendments, 1915). (*In the press*); Vol. III. 1*s.* (11*d.*)
Encounter. The Battle of. By Hans von Kiesling. Part I. Practical. Translated. 1*s.* 6*d.* (1*s.* 3*d.*)
Engineer Services Regulations. Peace:—Part 1. 1910. (Reprinted, with Amendments to May 1, 1915). 1*s.* (10*d.*) (*In the press*); Part 2. 1911. Technical Treatises. (Reprinted, with Amendments to May 1, 1915). 9*d.* (7*d.*) (*In the press*)
Engineer Training. 1912. (Reprinted, with Amendments, 1914). 6*d.* (6*d.*)
Engineering. Field. Manual of 1911. 9*d.* (9*d.*)
Engineering. Military:—
Part I. Field Defences. 1908. 1*s.* 6*d.* (1*s.* 3*d.*)
Part II. Attack and Defence of Fortresses. 1910. 9*d.* (8*d.*)

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Engineering. Military—*continued.*

Part III*a*. Military Bridging—General Principles and Materials. 1913. 1*s*. (11*d*.); Index. 1*d*. (1*d*.)

Part III*b*. Do.—Bridges. 1*s*. 3*d*. (1*s*. 2*d*.); Index. 1*d*. (1*d*.)

Part IV. Mining and Demolitions. 1910. 1*s*. (11*d*.)

Part V. Miscellaneous. 1914. 1*s*. (11*d*.)

Part VI. Military Railways. 1898. (*Out of print*)

Equipment Regulations:—

Part 1. 1912. (Reprinted with Amendments published in Army Orders up to Aug. 31, 1914). 1*s*. (11*d*.)

Part 2. Details—

Sect.

I. Infantry. (Regular Army.) 1913. 6*d*. (5*d*.)

I*a*. Mounted Infantry. 1912. 6*d*. (5*d*.)

II. Cavalry. (Regular Army.) 1914. 3*d*. (3*d*.)

III. Army Service Corps. (Regular Army). 1913. 6*d*. (5*d*.)

IV., IV*a*., and IV*b*. Army Ordnance Corps. Army Pay Corps. Army Veterinary Corps. (Regular Army.) 1914. 2*d*. (2*d*.)

V. Royal Army Medical Corps. (Regular Army.) 1914. 2*d*. (2*d*.)

VI.—IX. R.M. Academy; R.M. and Staff Colleges; Garrison Staff and Schools of Instruction; Military Prisons, Detention Barracks, and Military Provost Staff Corps. (Regular Army.) 1914. 2*d*. (2*d*.)

X*a*. Engineer. General. Fortress, Survey, Railway, and Depôt Units. Peace and War. (Regular Army.) 1914. 2*d*. (3*d*.)

X*b*. Field Troop. (Regular Army.) 1912. 2*d*. (2*d*.)

X*c*. Field Company. (Regular Army.) 1914. 2*d*. (2*d*.)

X*d*. Divisional Signal Company. (Regular Army.) 1914. 2*d*. (2*d*.)

Sect.

X*e*. Signal Company (Wireless). (Regular Army.) 1912. 2*d*. (2*d*.)

X*f*. Headquarters Signal Units. (Regular Army.) 1914. 2*d*. (2*d*.)

X*g*. Signal Company (Cable). (Regular Army.) 1912. 2*d*. (2*d*.)

X*h*. Signal Squadron. (Regular Army.) 1914. 2*d*. (2*d*.)

X*j*. Signal Troop with Cavalry Brigade. (Regular Army.) 1912. 2*d*. (2*d*.)

X*k*. Signal Troop with a Cavalry Brigade not allotted to a Cavalry Division. (Regular Army.) 1914. 2*d*. (2*d*.)

X*l*. Signal Company (South Africa). (Regular Army.) 1912. 2*d*. (2*d*.)

X*m*. Bridging Train. (Regular Army.) 1912. 2*d*. (2*d*.)

X*n*. Field Squadron. (Regular Army.) 1914. 2*d*. (2*d*.)

XI*a*. Horse Artillery. Q.F. 13-pr. (Regular Army.) 1913. 9*d*. (8*d*.)

XI*b*. Field Artillery. Q.F. 18-pr. (Regular Army.) 1914. 9*d*. (8*d*.)

XI*c*. Field Artillery. Q.F. 4·5-in. Howitzer. (Regular Army.) 1913. (Reprinted, with Amendments up to Aug. 1, 1914). 9*d*. (8*d*.)

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Equipment Regulations—*continued.*

Part 2. Details—*continued.*

Sect.
XI*d*. Reserve Brigades with Q.F. 18-pr. Equipment, Horse and Field Artillery, Staff and Depôts, Riding Establishment, School of Gunnery (Horse and Field), and Mounted Band (Regular Army). 1914. 6*d*. (6*d*.)

XI*e*. Mountain Artillery with B.L. 2·75-inch Equipment. Mountain Battery and Ammunition Column. Mule Transport. (Regular Army.) 1914. 6*d*. (5*d*.)

XII*a*. Royal Garrison Artillery. (Regular Army.) 1914. 2*s*. 6*d*. (1*s*. 11*d*.)

XII*b*. Royal Garrison Artillery. Siege Artillery, Movable Armament, and Machine Guns in Armaments. 1913. 1*s*. (10*d*.)

Sect.
XII*c*. Heavy Artillery. B.L. 60-pr. (Regular Army.) 1913. 9*d*. (8*d*.)

XIV. Cavalry School, Netheravon. (Regular Army.) 1914. 2*d*. (2*d*.)

XV. Camel Corps School, Egypt. (Regular Army.) 1914. 2*d*. (2*d*.)

XVI. Special Reserve. 1913. 4*d*. (4*d*.)

XVII. Officers Training Corps. 1912. 3*d*. (3*d*.)

Practice Batteries and Drill Guns (Fixed Mountings) of the Royal Garrison Artillery. (Part 2, Secns. XII*a* and XVI, and Part 3.) 1909. 1*s*. 6*d*. (1*s*. 2*d*.)

Part 3. Territorial Force. 1914. 6*d*. (6*d*.)
Do. Details:—
Sec. IX. Artillery. 1912. 1*s*. (9*d*.)
Do. Amendments, April 1912; Feb. 1914. Each 1*d*. (1*d*.)
Sec. X. Engineer. 1912. 3*d*. (3*d*.)
Amendments to Part 2. Feb., April, July (two issues), Aug. 1914. Each 1*d*. (1*d*.)
Amendments to Parts 1, 2 and 3. Nov. 1913. 1*d*. (1*d*.)
Amendments to Parts 1, 2 and 3. March, July 1913; April, Aug. 1914. Each 2*d*. (2*d*.)

Equipment. Infantry. Pattern 1908 Web. 1913. 2*d*. (2*d*.)

European War, 1914-15. Despatches (Naval and Military) relating to Operations in the War. Sept., Oct., and Nov. 1914. With List of Honours and Rewards Conferred. With Sketch Map. 2*d*. (3*d*.)

Examination Papers:—

Qualifying Certificates. Sept. 1905; March 1906; Sept. 1909; March, Sept. 1910; March, Sept. 1911; March 1912. Each 6*d*. (5*d*.)

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Examination Papers—*continued.*

Entrance: R.M. Academy, R.M. College, Qualifying Test for Commissions. Supplementary First Appointments in the Royal Marines. June-July 1912. 1*s.* (11*d.*)

Entrance: R.M. Academy, R.M. College, Qualifying Test for Commissions. Nov. 1912; Nov.-Dec. 1913. Each 1*s.* (11*d.*)

Entrance: R.M. Academy, R.M. College, Qualifying Test for Commissions. Supplementary First Appointments in the Royal Marines. Appointments in the Indian Police Force. Appointments in the Police Forces of the Straits Settlements and the Federated Malay States. Cadetships in the Royal Navy (Special Entry). June-July 1914. 1*s.* (11*d.*)

Entrance: R.M. Academy, R.M. College. Nov.-Dec. 1914. 1*s.* (10*d.*)

Freehand Drawing at the Army Entrance Examination of Nov. 1913. Specimen Paper to illustrate the kind of questions that will be set in. 6*d.* (5*d.*)

R.M. Academy, Fourth Class; **R.M. College,** Fourth, Third, and Second Divisions. July, Dec. 1904; June 1905. Each 1*s.*

R.M. Academy, Fourth Class; **R.M. College,** Senior Division. Dec. 1905; June, Dec. 1906; July, Dec. 1907. Each 1*s.*

Staff College. Admission. Aug. 1907; Aug. 1909; July 1911; June-July 1912; June-July 1913. Each 1*s.* (6*d.*)

Regular Forces, Canadian Permanent Forces, Special Reserve of Officers, Territorial Force, and Colonial Military Forces. May, Nov. 1906; May, Nov. 1908. Each 1*s.* (11*d.*)
Do. May 1909. 9*d.* (8*d.*)

Officers for Promotion. Dec. 1912; May, Dec. 1913; April 1914. Each 1*s.* (6*d.*)

Militia, Imperial Yeomanry, and University Candidates. March, Sept. 1904; Sept. 1905; Oct. 1906. Each 1*s.*

Special Reserve, Militia, Territorial Force, and University Candidates. Oct. 1911; March, Oct. 1912; March, Oct. 1913. Each 1*s.* (6*d.*)

Special Reserve, Militia, Territorial Force, Non-Commissioned Officers, and University Candidates. March 1914. 1*s.* (6*d.*)

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Examination Papers—*continued.*

Officers Training Corps :—

Cadets of the Senior Division. Certificate A. Dec. 1908. 6*d.* (5*d.*)

Cadets of the Junior and Senior Divisions. Certificates A and B. Spring of 1909 ; Nov. 1910 ; May, Nov. 1911 ; March, Nov. 1912 ; March, Nov. 1913 ; March 1914. Each 6*d.* (6*d.*)

Foreign Languages. Modern. July 1906 ; July 1908 ; April, July 1909 ; Jan., June, Oct. 1910 ; Jan., June, Oct. 1911 ; June 1912 ; June 1913 ; June 1914. Each 1*s.* (6*d.*)

Explosives. Service. Treatise on. 1907. 1*s.* 6*d.* (1*s.* 2*d.*)

Field Almanac. 1915. 1*d.* (1*d.*)

Field Service Manuals :—

Artillery. Field. Brigade. Q.F. 18-pr. 1915. 3*d.* (3*d.*) (*In the press*)

Do. Do. (Howitzer) Brigade. 5-inch B.L. 1908. 3*d.* (3*d.*)

Do. Heavy. (B.L. 60-pr.) Battery and Ammunition Column. Expeditionary Force. 1910. 3*d.* (3*d.*)

Do. Horse. Brigade. 13-pr. Q.F. 1908. 3*d.* (3*d.*) (*Under revision*)

Do. Do. Appendix to. R.H.A. Battery and Mounted Brigade Ammunition Column. 1*d.* (1*d.*)

Cavalry Regiment. Expeditionary Force. 1913. 3*d.* (3*d.*) (*Under revision*)

Engineers. Balloon Company. Expeditionary Force. 1910. 3*d.* (3*d.*)

Do. Bridging Train. Expeditionary Force. 1915. 3*d.* (3*d.*)

Do. Field Company. Expeditionary Force. 1915. 3*d.* (3*d.*)

Do. Field Squadron. Expeditionary Force. 1914. 3*d.* (3*d.*)

Do. Works Company. Expeditionary Force. 1910. 3*d.* (3*d.*)

Headquarters Units. Expeditionary Force. 1911. 3*d.* (3*d.*)

Infantry Battalion. Expeditionary Force. 1914. 3*d.* (3*d.*)

Infantry (Mounted) Battalion. Expeditionary Force. 1913. 3*d.* (3*d.*)

Medical Service. Army. Expeditionary Force. 1914. 3*d.* (3*d.*)

Signal Service. Signal Company (Air-line). Expeditionary Force. 1913. 3*d.* (3*d.*)

Do. Signal Company (Cable). Expeditionary Force. 1913. 3*d.* (3*d.*)

Do. Signal Company (Divisional). Expeditionary Force. 1915. 3*d.* (3*d.*)

Do. Signal Company (Lines of Communication). Expeditionary Force. 1914. 3*d.* (3*d.*)

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Field Service Pocket Book. 1914. 1*s.* (11*d.*)

Field Service Regulations:—

Part I. Operations. 1909. (Reprinted, with Amendments, 1914). 6*d.* (6*d.*)
Part II. Organization and Administration. 1909. (Reprinted, with Amendments to Oct. 1914). 1*s.* (10*d.*)
Do. Amendments, April 1915. 1*d.* (1*d.*)

Financial Instructions in relation to Army Accounts. 1910. (Reprinted, with Amendments to Sept. 1, 1914). 4*d.* (4*d.*)

Flying Corps. Royal. Training Manuals:—
Part I. Provisional. 1914. 1*s.* (10*d.*)
Do. Amendments. Jan. 1915. 1*d.* (1*d.*)
Part II. Military Wing. Provisional. 1914. 3*d.* (4*d.*)

Foreign Languages. Study of. Regulations. 1913. 2*d.* (2*d.*)

Fortification. Permanent. For the Imperial Military Training Establishments and for the Instruction of Officers of all Arms of the Austro-Hungarian Army. 7th Edition. Translated. 4*s.* (2*s.* 11*d.*)

Franco-German War, 1870-71. Translated from the German Official Account:—

First Part—History of the War to the Downfall of the Empire—
Vol. 1 (Secns. 1 to 5). Outbreak of Hostilities to Battle of Gravelotte. (*Out of print*)
Vol. 2 (Secns. 6 to 9). Battle of Gravelotte to Downfall of the Empire. (*Out of print*)

Second Part—History of the War against the Republic—
Vol. 1 (Secns. 10 to 13). Investment of Paris to Re-occupation of Orleans by the Germans. £1 6*s.* (18*s.* 6*d.*).
Vol. 2 (Secns. 14 to 18). Events in Northern France from end of Nov. In North-west from beginning of Dec. Siege of Paris from commencement of Dec. to the Armistice. Operations in the South-east from middle of Nov. to middle of Jan. £1 6*s.* (19*s.*)
Vol. 3 (Secns. 19 and 20). Events in South-east France from middle of Jan. to Termination of Hostilities. Rearward Communications. The Armistice. Homeward March and Occupation. Retrospect. £1 11*s.* 6*d.* (£1 2*s.* 3*d.*)

Also separately, Sections in paper covers, and Plans unmounted:—

Section.
1. Events in July. Plan. 3*s.* (2*s.* 2*d.*)
2. Events to Eve of Battles of Wörth and Spicheren. 3rd ed. (*Out of print*)
3. Battles of Wörth and Spicheren. 3rd edition. (*Out of print*)
4. Advance of Third Army to the Moselle, &c. 2nd edition. (*Out of print*)
5. Operations near Metz on 15th, 16th, and 17th August. Battle of Vionville—Mars la Tour. 2nd edition. (*Out of print*)

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Franco-German War—*continued.*

Section—*continued.*

6. Battle of Gravelotte—St. Privat. (*Out of print*)
7. Advance of Third Army and of Army of the Meuse against Army of Chalons. (*Out of print*)
8. Battle of Sedan. (*Out of print*)
9. Proceedings on German Coast and before Fortresses in Alsace-Lorraine. Battle of Noisseville. General review of War up to Sept. 4*s.* 6*d.* (3*s.* 4*d.*)
10. Investment of Paris. Capture of Toul and Strassburg. 6*s.* (4*s.* 6*d.*)
11. Events before Paris, and at other points of Theatre of War in Western France until end of October. 5*s.* 3*d.* (3*s.* 11*d.*)
12. Last Engagements with French Army of the Rhine. Occurrences after fall of Strassburg and Metz to middle of November. 4*s.* 6*d.* (3*s.* 5*d.*)
13. Occurrences on Theatre of War in Central France up to Re-occupation of Orleans by the Germans. 6*s.* (4*s.* 6*d.*)
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ABBREVIATIONS.

A.P.	...	Armour piercing.
A.T.C.	...	Anti torpedo craft.
B.C.	...	Battery commander.
B.L.	...	Breech loading.
B.L.C.	...	Breech loading converted.
C.C.D.	...	Commander of coast defences.
C.P.	...	Central pivot.
D.R.F.	...	Depression range-finder.
E.L.D	...	Electric light director.
E.M.F.	...	Electromotive force.
F.C.	...	Fire commander.
F.G.	...	Fine grain.
f.s.	...	Feet per second.
G.C.	...	Gun captain.
G.G.C.	...	Gun group commander.
G.L.	...	Gun layer.
G.S.	...	General service.
H.A.	...	High angle.
H.E.	...	High explosive.
H.P.	...	Hydro-pneumatic.
K.C.	...	Krupp cemented.
K.N.C.	...	Krupp non cemented.
L.G.	...	Large grain.
M.D.	...	Modified (cordite).
M.L.	...	Muzzle loading.
M.P.I.	...	Mean point of impact.
M.S.L.	...	Mean sea-level.
M.V.	...	Muzzle velocity.
P.	...	Prism.
P.E.	...	Permissible error.

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P.F.	Position finder.
Q.E.	Quadrant elevation.
Q.F.	Quick firing.
R.B.L.... ...	Rifled breech loading (Armstrong).
R.F.G.... ...	Rifled fine grain.
R.M.L. ...	Rifled muzzle loading.
R.T.	Range table.
T.E.	Tangent elevation.

SYMBOLS.

w	Weight of projectile in pounds.
d	Diameter of projectile in inches.
V	Initial velocity in feet per second.
v	Final velocity in feet per second.
t	Time of flight in seconds.
ϕ	Angle of projection.
a	Angle of sight.
β	Angle of descent.
g	The acceleration due to gravity.
ω	Ohms.

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DEFINITIONS.

Calibre.—The diameter of the bore in inches, not counting the depth of the grooves.

Axis of the Piece.—A line passing down the centre of the bore. AB, Fig. 1.

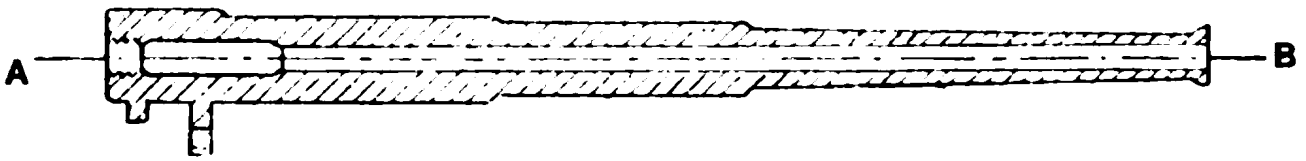

Fig. 1.

Axis of the Trunnions.—A line passing through the centre of the truunions. With trunnionless guns the trunnions of the cradle are referred to.

Line of Sight—A line passing through the sights of the piece and the point aimed at. CF, Fig. 2, and GT, Fig. 3.

Line of Fire.—The straight line joining the muzzle of the piece and the target.

Angle of Sight.—The angle which the line of sight makes with the horizontal plane. S, Fig. 2.

Angle of Elevation.—The angle which the axis of the piece makes with the line of sight. T, Fig. 2.

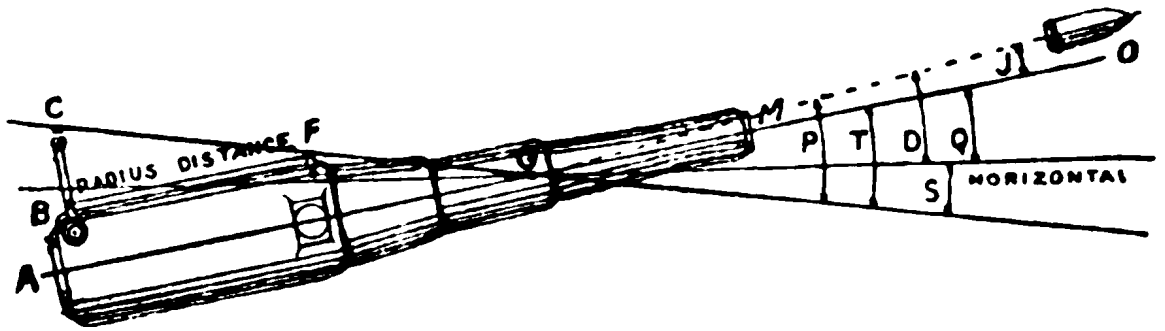

Fig. 2.

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This is sometimes called the "Tangent Elevation" to distinguish it from "Quadrant Elevation" (*see* Quadrant Angle).

Quadrant Angle.—The angle which the axis of the piece makes with the horizontal plane. It is termed quadrant elevation or depression according as the piece is laid above or below the horizontal plane. Q, Fig. 2. *Note.*—The angle of elevation and the quadrant angle are the same when the line of sight is horizontal.

Jump.—The angle between the axis of the piece before firing and the line of departure. J, Fig. 2. It is due to the movement of the gun on firing, and, for any gun, differs according to the mounting and the charge used.

Line of Departure.—The direction of the projectile on leaving the muzzle, in other words, a tangent to the trajectory at the muzzle. Dotted line, Fig. 2.

Angle of Departure.—The angle between the line of departure and the horizontal plane. D, Fig. 2.

Angle of Projection.—The angle between the line of departure and the line of sight. This is equal to the angle of elevation + that of jump (negative jump is subtracted). P, Fig. 2.

Drift.—The continual deviation of the projectile from the plane of departure, due to the rotation imparted by the rifling of the piece. When rifling has right-handed twist, drift is to the right.

Trajectory.—The curve described by the projectile in passing from the muzzle to the first point of impact. GPS, Fig. 3.

Range.—This term is generally used to denote the distance from the gun to the target. GT, Fig. 3.

The range due to a particular angle of elevation is the distance from the gun to the (in some cases second) inter-

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section of the trajectory with the line of sight. GP, Fig. 3. In this case, owing to insufficient elevation, the shot falls short at S.

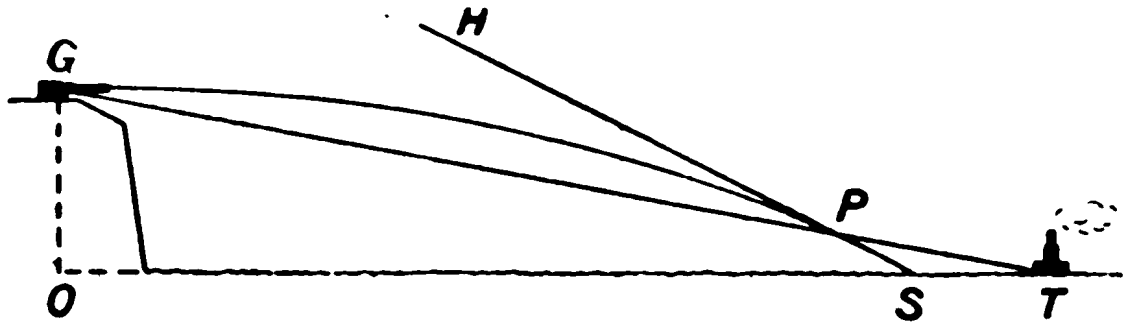

Fig. 3.

Angle of Descent.—The angle made by a tangent to the trajectory with the line of sight, at the point where they intersect. HPG, Fig. 3.

Angle of Arrival.—The angle which the tangent to the trajectory at the first point of impact makes with the horizontal plane. PSO, Fig. 3. (*Note* that on the small scale of the figure it is impossible to show separately the trajectory and tangent between P and S.)

If the correct elevation is given to the gun, the points P, S, and T will coincide and the angle of arrival is equal to the angle of descent + the angle of sight.

Dangerous Space for any Target.—The horizontal distance in which the trajectory would pass through any portion of it. For instance, a shell with a slope of arrival of 1 in 10 would hit the side of a vessel of 20 feet freeboard over a space of 200 feet, and if the target had 60 feet beam, the dangerous space would be 260 feet.

Muzzle Velocity.—The velocity in feet per second with which a projectile leaves the muzzle.

Remaining Velocity.—The velocity of a projectile at any given point of its trajectory.

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Striking Velocity.—The velocity of a projectile at the point of impact.

The Artillery Armament is divided into (a) Fixed Armament, and (b) Armament for the protection of land fronts at home, or Movable Armament abroad.

(a) *Fixed Armament.*—That which is mounted in fixed positions in forts or batteries.

The guns of the fixed armament are classified as follows :—

Heavy.—All guns above 6-inch B.L.

Medium.—6-inch B.L. to 4·7-inch Q.F.

Light.—Includes the light Q.F. guns (4-inch Q.F. and under).

(b) *Armament for the protection of land fronts at home, and Movable Armament abroad,* consists of those guns, howitzers, quick-firing guns, and machine guns which are so mounted as to be capable of being moved and brought into action in various positions.

Alarm Circuit.—A system by which A.T.C. batteries are warned of the approach of hostile craft from an outer look-out post.

Obstructions by Sea.—Impediments to navigation, either permanent, such as breakwaters, or temporary, such as booms.

Electric Light Director.—The officer or N.C.O. who regulates the movement of an electric light under the orders of a fire commander or battery commander.

Fortress Commander.—The officer in chief command of a coast fortress or defended port.

Section of Defence.—A sub-division of a coast fortress for purposes of organization and fighting. This sub-division only exists in the larger fortresses.

Section Commander.—The officer in command of a section of a coast fortress or defended port.

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Fire Command.—A sub-division of a fortress, or section, for purposes of fighting the fixed armament. It is the highest unit of executive artillery command.

Fire Commander (F.C.).—The artillery officer responsible for the efficiency, as a fighting unit, of a fire command.

Battery Command.—A sub-division of a fire command, consisting of such a number of gun groups, with all personnel and *matériel* necessary for fighting them, as may be efficiently commanded by one officer.

Battery Commander (B.C.) —The officer in command of a battery command.

Gun Group.—One or more adjacent guns of the same nature placed under the command of an officer or N.C.O.

Gun Group Commander (G.G.C.).—An officer or N.C.O. in command of a gun group.

Gun Captain (G.C.).—The N.C.O. commanding a single gun complete with its detachment and stores.

Displacement.—The distance between a gun (or group) and the range-finding instrument by which it is fought.

Gun (or Group) Difference. —The difference at any moment between the range from the gun (or group) to the target and the range from the range-finder.

Command Post.—The building, cell, or position selected to be occupied by the commander of any unit during action.

Fire Control.—The general conduct of any system of artillery defence by the officer in superior command, both previous to and during action.

Fire Direction.—The conduct during action of the artillery fire in accordance with the orders of the officer holding fire control.

Fire Discipline.—That combination of qualities by which effective fire is brought to bear on a selected objective in the shortest possible time, and maintained on that objective

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GARRISON ARTILLERY TRAINING.

VOL. I.—1914.

CHAPTER I.

PRINCIPLES OF TRAINING.

1. *General remarks.*

1. The sole object of military training is to prepare our forces for war, success in battle being constantly held in view as the ultimate aim.

2. The principles to guide our forces in war and our training in peace are laid down in F.S. Regs., Part I, and in the T. and M. Regs., and the instructions in this Manual are in amplification of these regulations.

3. The training of the artillery soldier is designed to fit him mentally and physically to do his duty in war. To attain this object the preliminary steps necessary are :—

i. The training of the soldierly spirit.
ii. The training of the body.
iii. The training in artillery weapons.

After satisfactory progress in these essentials has been made the soldier must be taught how he can apply what he has learnt to the varied conditions which will confront him in war.

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4. The objects in view in developing a soldierly spirit are to help the soldier to bear privation and danger cheerfully; to give him confidence in his superiors and in himself; to teach him to act in conjunction with his comrades; to train him to obey orders, or to act in the absence of orders for the advantage of his unit under all conditions; and, finally, to produce such a high degree of courage and disregard of self that he will carry out his duties in action coolly and accurately.

5. The artilleryman should be instructed in the deeds which have made the British Army and the Royal Artillery famous, and should be given every opportunity of inspecting and hearing the history of any trophies which may be available and which would tend to develop his military spirit and pride in the Regiment.

6. The object of training the body is to develop in the soldier a capacity for resisting fatigue, and to enable him to carry out his duties under adverse physical conditions.

7. Manly games are of value, especially if such games and competitions are so arranged that all, and not only selected teams, take their part. Games and competitions should be used to impress upon all the power of combination as well as of individual prowess and the importance of playing for one's side and not for oneself.

Responsibility for Training.

2. *Lieutenant-colonel commanding.*

1. **The lieutenant-colonel is responsible for the training and efficiency of the companies under his command.** It is not possible to do more than indicate some of the directions in which his authority can be most usefully exercised. They are :—

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i. The training of company officers in the duties of B.C. and the details of range-finding. (App. III.)
ii. The training of officers in their mobilization duties.
iii. The periodical testing of the war communications.
iv. Promulgating and practising suitable distribution of fire schemes both for anti-torpedo craft armament and for guns employed by day.
v. Testing the efficiency of all range-finding instruments.
vi. Instructing regimental officers in such portions of the local Defence Scheme as should be known by them, and also in the regulations for the entry of H.M.'s ships and the control of mercantile traffic.

2. He will also arrange for the following :—

i. Formation of classes for the training of telephonists and range-finding specialists and also for training N.C.Os. as instructors.
ii. Instruction of officers in signalling.
iii. The examination and classification of company specialists for proficiency pay under the Pay Warrant in accordance with the King's Regulations. Cases occur owing to change of station and for other reasons when the period of the annual proficiency pay qualification of an N.C.O. or man expires before the next general examination of the company. Arrangements should be made for special examinations to be held at any time in the year, so that any N.C.O. or man who desires to re-qualify may have the opportunity of doing so before the period of his qualification expires. No man who has failed at an examination may be examined again in the same proficiency year.

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iv. The assistance of gunnery instructors and assistant gunnery instructors at such times as their services may be available.

v. The arrangement of a series of lectures on technical subjects by officers during the winter months.

3. The lieutenant-colonel commanding will usually be detailed to command the Fire Command manned on mobilization by the companies under him and in this case he will be responsible for the organization of his Fire Command.

Should he be detailed to command a Section of Defence on mobilization, he will be responsible for the organization of his section as well as for all the Fire Commands included in it.

3. *Company commander.*

1. The company commander is responsible to the lieutenant-colonel for the training and efficiency of all officers and men of his company.

4. *Section officer.*

1. A company R.G.A. is sub-divided into sections, each section being under the command of an officer, and comprising, as far as possible, the complete manning detail and *matériel* of a group or battery command. Each officer should be given a definite responsibility in accordance with the duties allotted to him in war.

2. The officer commanding a section of a company will be responsible to his company commander for the personnel of his command, and also for seeing that the *matériel* of his group or battery command is up to date and in a fit condition for immediate use.

3. He should know the capabilities of every man in his section, note those who are likely to make good specialists,

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and give them the necessary elementary instruction before they join the classes formed for their special training. He should be intimately acquainted with the *matériel* of his command.

4. The number of sections in a company will depend on the number of groups or battery commands the company is required to man on mobilization.

5. *Gunnery instructors.*

1. Instructors in gunnery are under the orders of the C.C.D. except where a commander of Royal Artillery has been appointed. In the latter case they are under the orders of this Commander, Royal Artillery. At stations abroad the instructors in gunnery are under the orders of the C.R.A.

2. The duties of chief instructors and instructors in gunnery in Commands are as follows :—

(*a*) Advice to the C.C.D. (or C.R.A.) on questions affecting gunnery and gunnery training, on the arrangements for practice, calibration, practice reports, &c., and for such executive action in these matters as the C.C.D. (or C.R.A.) may direct.

(*b*) Assistance and advice to regimental officers regarding the setting up, adjustment, care, and use of all range-finding instruments, electrical equipment telephones, &c. Regimental officers, however, are entirely responsible for the efficiency of the whole of their equipment in peace and war.

(*c*) Assistance to regimental officers and men during the individual and to companies during the collective training periods in all gunnery matters.

(*d*) Assistance in instruction of Special Reserve, Terri-

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torial Force, and local artillery, especially during their annual courses, week end camps, fort mannings, &c.

(*e*) Holding courses in artillery subjects at the local schools of gunnery and in the station.

3. Gunnery instructors will take part in the exercises referred to in Secs. **14** to **17**. The C.C.D. (or C.R.A.) will arrange that gunnery instructors are afforded ample opportunity of practising the duties allotted to them during the precautionary and war periods.

4. The main duty of gunnery instructors and assistant gunnery instructors in peace is to impart direct instruction to all ranks, including the Special Reserve and Territorial Force, by means of courses, lectures, &c., and the maximum of time should therefore be spent with troops and the minimum of time in the office.

6. *Armament officers and district officers.*

1. *Armament officers*—

The C.R.A. should usually allot armament officers to companies, placing them under the orders of the company commander.

Where this is unsuitable the C.R.A. will issue detailed orders as to their duties.

Armament officers should in any case undergo an annual company and regimental course, and take part in the various exercises referred to in Secs. **14** to **17**.

They will be exercised periodically in the duties allotted to them in the precautionary and war periods.

They should undergo, in their turn, the various courses held at the station and elsewhere.

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2. *District officers—*

District officers will not, as a rule, be allotted permanently to companies, unless the C.R.A. considers it advisable.

Except for this they will be trained as far as possible in the same manner as armament officers.

The C.R.A. will draw up a list of their duties, and will ensure that these officers are thoroughly proficient in the tasks allotted to them in the precautionary and war periods.

7. *Individual and collective training.*

1. The periods of individual and collective training are stated in the T. and M. Regs.

Individual training should also be continued during the collective training period as opportunities permit, whilst certain collective training exercises will be carried out periodically throughout the year.

Individual Training.

8. *Instruction of officers.*

1. Instruction will be both theoretical and practical, and should be arranged so as to train an officer not only in the technical subjects required by him as a garrison artilleryman, but also to give him such general military knowledge as will fit him for the performance of any duties that might fall to him when serving with an army in the field. This latter is especially the duty of the lieutenant-colonel.

2. Individual instruction should consist of :—

i. Theoretical instruction by means of lectures on technical and military subjects.

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ii. Practical instruction in technical subjects by means of local courses.

Officers are to be instructed in range-finding duties, and the details of setting up and adjusting the range-finding instruments. (*See* Appendix III (A).)

iii. Practical instruction in military subjects and in the combined operations of all arms by means of regimental and other exercises, and by attachment to other arms. (*See* T. and M. Regs.)

3. In addition to the above, officers will be instructed in all the duties which fall to them under the local defence scheme, and also in the general provisions of this scheme.

Officers should also be employed in reconnaissance, topographical and other work in connection with the local schemes of defence.

Practical and written tests should be made of the knowledge possessed by all officers, of the duties that may be required of them prior to and in action, and of the organization for defence to meet every form of attack to which the command in which they are serving is liable.

Written exercises will be criticized in writing by commanders of companies and lieutenant-colonels, who will cause their remarks to be communicated to the officers concerned. Any exceptionally good exercises may be forwarded for the information of the Commander of Coast Defences, or, if abroad, of the G.O.C.

4. Arrangements have been made by which facilities will be accorded by the Royal Navy for selected officers to witness target practice from His Majesty's ships. Similarly, naval officers are to be permitted, on application being made through the proper channel, to witness the methods of defence employed in coast batteries against attacking vessels.

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Commanders of Coast Defences at home and General Officers Commanding abroad will place themselves in communication with the Senior Naval Officers at the different ports, with a view to giving effect to this arrangement.

Information gained in the above circumstances is confidential.

5. **One of the most important duties of an artillery officer of whatever rank is the cultivation of his powers of observation of fire.**

Ineffective fire is frequently due to faulty observation on the part of the battery commander.

The best trained detachments are of no avail unless the fall of the rounds is accurately observed and rapidly corrected. Moreover, officers who have not carried out gun practice for several years find their powers of observation impaired by lack of practice.

All officers must, therefore, take every opportunity of attending gun practice over land and sea ranges, and by so doing maintain and increase their observing powers.

At such practices they will record their own observations.

After the practice the observations should be compared with the report of the range officer.

Lieutenant-colonels commanding should inspect these records and personally supervise the training of their officers in this respect.

9. *Instruction of men.*

A.— Instruction of recruits at depôts.

1. The training of recruits will begin as soon as they join the depôt.

Recruits should be formed into squads of eight to ten men each, according to service.

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2. Commanders of depôts will arrange programmes of training to suit local conditions and the varying capacity of recruits. In doing this, the importance of first preparing the mind and body, so that the recruit may gain full benefit from the subsequent instruction which he receives on joining his company, must be borne in mind. The daily programmes of work should be arranged with as great variety as is possible, and must be suited to the aptitude of the individual recruit; every endeavour must be made to guard against monotony, with its consequent loss of interest. Where guns of modern pattern are available near the depôt, gun drill should begin as soon as possible. The whole course may occupy about twelve weeks, but the time for the conclusion of the course is not to be gauged by the number of drills performed, but by the proficiency of the individual recruit.

3. The programme of the course should normally comprise the following subjects :—

i. **The training of the soldierly spirit.** (*See* **Sec. 1.**) **The development of this spirit at the outset of a soldier's career is of the highest importance, and the officer commanding the depôt should pay personal attention to this point.**

ii. Instructions in barrack and camp duties, cleanliness, smartness, orders, and necessary regulations.

iii. Physical training, under qualified instructors, as laid down in the "Manual of Physical Training."

iv. Foot drill, musketry and rifle exercises. (*See* "Infantry Training" and "Musketry Regulations, Part I.") The Royal Garrison Artillery will drill as laid down for infantry other than Rifle Regiments.

The average recruit should be able to take his place in the ranks of the company at drill with arms, and should understand the care, mechanism,

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and sighting of the rifle, adjustment of sights, and be able to aim correctly in the various firing positions.

v. Repository work and the use of simple mechanical appliances.

An elementary knowledge of principles and such details as are generally applicable.

vi. Cordage, tackles, knotting, and lashing.

A general knowledge of their use and instruction in making the simpler knots and lashings.

vii. Gunnery, including gun drill and laying, mountings, and ammunition.

An elementary knowledge applicable to all types of guns.

viii. Boys on joining the depôt will also be instructed in signalling, the use of telephones, map-reading, and carrying messages.

4. Recruits should be sent to a service company in squads.

B.—Instruction of men in the company.

1. The instruction at the depôt detailed in the previous paragraphs will be continued when a recruit joins a company so as to ensure that all training is systematic and progressive. **Great importance must be attached to the development of the soldierly spirit.**

2. The recruit will be put through a complete course of gun drill with the guns manned by the company on mobilization, He will likewise be instructed in the elementary principles of gunnery.

3. The "young soldier" will be instructed generally in the guns, mountings, and ammunition in charge of the company,

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and specially in everything connected with the group or battery command to which he is allotted on mobilization. He should be instructed in gunnery, and in light repository exercises.

Musketry training will be carried out in accordance with "Musketry Regulations, Part I."

Recruits who have not completed the course of physical training on leaving the depôt should be put through the uncompleted part of the course on joining their company. Trained soldiers will be put through the course contained in the "Manual of Physical Training."

The soldier will be instructed in accordance with "Infantry Training," "Ceremonial," Chapter IV, and the "Manual of Field Engineering," so as to be able—

i. To take his place in the ranks of his company at ceremonial parades and to carry out the annual course of musketry.
ii. To perform garrison and regimental duties.
iii. To assist infantry in repelling an attack on prepared positions.
iv. To carry out camping arrangements.

4. The knowledge of the trained soldier should be kept up by drill and periodical lectures. He will be taught the drill of all the guns in the station, whether of the fixed or movable armament. He should also be taught semaphore signalling.

Practical gunnery and description of guns, mountings, gears, &c., should be taught at the gun, but everything connected with the theory of gunnery, and all subjects which can best be taught indoors, will be explained, as a rule, by an officer by means of lectures. Models and the black board will be used for such lectures, and all available facilities for

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making the men take an interest in their instruction will be employed. They will be given the best instructors and the best accommodation available, for men can hardly give due attention to, or profit by, explanations of theory, &c., conveyed to them by an indifferent instructor, or when standing in the cold or wet under circumstances of physical discomfort.

5. The best of the trained soldiers will be selected for special instruction as layers, range takers, signallers, and telephonists.

Company commanders will arrange for the systematic instruction of these specialists throughout the year and lieutenant-colonels are responsible that a suitable number of specialists of all kinds is maintained.

Instructions regarding the training and examination of range takers and gun layers will be found in Appendices III and IV respectively.

For the training of signallers, *see* "Training Manual—Signalling."

For the training of telephonists, *see* Sec. 121, and Appendix VI.

10. *Courses of individual instruction.*

Courses for the individual instruction of officers and men are held at Shoeburyness, at local Schools of Gunnery, and at Lydd.

Collective Training.

11. *General instructions.*

1. The collective training of units must be systematic and progressive. Commencing with the personnel of a group,

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it will progress through the successive steps of battery command and fire command to sections of defence and to the whole fortress.

2. Wherever possible, local arrangements should be made to give company commanders all their men on one day in each week for manning the groups and batteries to which they are allotted on mobilization or during the precautionary period.

3. Conferences of lieutenant-colonels and company commanders, R.G.A., should be held at the end of the collective training season under the direction of the C.C.D. or G.O.C., assisted by the O.C., R.G.A., and the chief instructor in gunnery, to discuss points of training and practice brought to notice during the season, and to consider improved methods for the following season.

12. *Company courses.*

1. To enable company commanders to train the personnel of their companies, all companies will, if possible, be struck off duty annually for at least five weeks to enable them to undergo a company course.

2. In the United Kingdom company courses will take place at times to be arranged by the C.C.D., and usually between 1st February and 1st June. Battery practice should be carried out after the company course is completed.

3. At stations abroad, company courses will be carried out at times best suited to local and climatic conditions, but the total duration of the course will never be shortened.

4. Lieutenant-colonels should visit their companies as frequently as possible during their company courses and supervise the instruction.

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13. *Regimental courses.*

1. When all the companies of a lieutenant-colonel's command have undergone company courses and have completed their battery practice, the whole lieutenant-colonel's command will be struck off duty for the purpose of undergoing a regimental course under the lieutenant-colonel.

2. The purpose of the regimental course is to train fire commands for war.

3. If it is impracticable to strike the whole lieutenant-colonel's command off duty simultaneously, the manning details of a fire command will be struck off duty in succession to undergo a regimental course under the F.C. in question.

4. The duration of a regimental course should never be less than four weeks, if possible longer.

During the last week of the regimental course the Fire Command should be mobilized, the personnel living in the batteries and works allotted to them on mobilization, and war routine instituted.

5. During the regimental course a certain amount of fortress practice should be carried out.

14. *Artillery practice mobilization.*

1. Once a year, after all companies in the station have completed their regimental courses, the artillery of a coast fortress or defended port will carry out a practice mobilization of the defences, when officers and men will proceed to their war stations and war routine will be instituted.

2. The C.C.D. or the G.O.C. will decide whether practice is to be carried out during this mobilization.

3. The co-operation of other arms should be obtained, and for this reason the artillery mobilization will usually coincide

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with a practice mobilization of the fortress, and as a rule will take place in conjunction with one of the defence exercises enumerated in Sec. 17.

4. Arrangements should, if possible, be made with the Royal Navy to carry out various forms of attack on the coast fortress or defended port during this period.

The entry of H.M. ships and the examination service should also be practised if possible.

15. *Communication exercises.*

1. Once a month throughout the year a communication exercise should be held for the purpose of practising all the communications within, and as many as possible outside, the chain of artillery command.

2. The messages sent should not be confined to those concerning the fighting of the batteries, but should include administrative messages regarding ammunition, supplies, casualties to personnel and *matériel*, &c.

3. Occasional messages should be sent in cipher.

4. Arrangements should be made for sending messages from F.Cs. to those outside the chain of artillery command and *vice versâ*, including central offices representing the Fortress Commander, Section Commander or C.R.A.

5. Messages should be considerable in number so as to impose a severe strain on the telephone lines and personnel, and casualties in both should be practised.

6. On the completion of the exercise, all messages should be forwarded to the officer in charge of signals, who is responsible for the communications of the fortress.

7. Communication exercises should usually last about two hours.

At night B.Cs. and G.G.Cs. open fire on their own

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initiative, fighting and administrative messages should be reduced to a minimum; communication exercises, therefore, should usually take place by day.

It is not necessary to combine these with manning exercises, as gun detachments are not essential.

8. Instructions regarding telephone messages will be found in Appendix VI.

16. *Manning exercises.*

1. Periodical mannings of the various works will take place throughout the year.

They will be practised by day and night, both on the precautionary and on the war period manning tables.

2. The artillery personnel will, as a rule, man those guns, &c., to which they are allotted in war, but when the required numbers are not available, and it is desired to practise the complete manning of any particular work, the manning detail may be completed to its proper numbers from any available source.

One or more works at a time should occasionally be manned in this way in order to gain experience in accommodating the complete war personnel in a work and in practising a suitable system of war routine.

3. Arrangements should be made to obtain the co-operation of the other arms allotted to the work.

The co-operation of the infantry should not be confined to the periods of fortress mobilization.

When infantry is available, an attack on the works so manned should be carried out to test the infantry defences.

4. Officers and men of the Special Reserve and Territorial Force should be encouraged to take part in as many mannings as possible, so as to carry out drills, &c., in their

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war stations and to familiarize themselves with war conditions by day and night.

5. The artillery personnel will carry out the practice of fire control and fire direction in the various fire commands, and the system of defence against the various forms of attack to which the defended port is liable will be practised. The practice of the rules for the examination service and the entry of H.M. ships should also take place where possible.

7. At day manning exercises a certain amount of practice should occasionally take place. This may be carried out with either service, sub-calibre, or 1-inch aiming rifle ammunition, at least one complete fire command, where possible, carrying out a combined series.

8. **Night mannings, as far as the artillery is concerned, are required to accustom the personnel generally to night conditions, and—**

(*a*) **To practise the tactical control of the electric lights.**

(*b*) **To train gun layers in night laying with the guns allotted to them in war, and to practise distribution of fire.**

(*c*) **To exercise the manning detail in their duties at night, including the posting and proper relief of watches, and their accommodation in the gun floor shelters and elsewhere. (Chapter V.)**

(*d*) **To practise the ammunition supply, the communications, and the alarm circuit.**

(*e*) **To practise, as far as possible, the rules for the examination service and the entry of H.M. ships.**

9. Night mannings in conjunction with the Royal Engineers should take place once a month, and where possible once a fortnight.

If it is not possible to man all the lights on one night, it

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will be necessary to carry out two night mannings in succession, a portion of the lights and works being manned on each occasion.

10. At night mannings, distribution of fire should where possible be practised, using service, sub-calibre, 1-inch aiming rifle, or blank ammunition.

17. *Defence exercises.*

1. A defence exercise is a combined exercise carried out by the local naval and military authorities at a defended port, for the purpose of testing one or more of the undermentioned :—

(*a*) The arrangements for the entry of H.M. ships into a defended port.
(*b*) The examination service.
(*c*) The efficiency of the shore defences against attacks made by ships or torpedo craft by day and night.
(*d*) Other operations in connection with defence matters, including attacks by landing parties.

2. The general principle to be followed is that at least one summer and one winter defence exercise should be carried out annually.

(*a*) Summer defence exercises should be for the purpose of testing and training the actual personnel allotted in war, and of practising the examination service, entry of H.M. ships, and general defence of the fortress, and the tests should be as long as necessary for these purposes.

(*b*) Winter defence exercises should be for the purpose of carrying out the above with the personnel available, so as to gain as much experience of winter conditions as possible.

(*c*) In addition to the normal summer and winter exercises, intermediate defence exercises should be carried

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out occasionally, for the purpose of testing any of the defensive arrangements at the discretion of the local naval and military authorities.

3. The procedure for arranging these defence exercises is laid down in "Procedure for Carrying out Defence Exercises at Defended Ports."

4. The artillery will participate in defence exercises under the orders of the C.C.D. or G.O.C.

18. *Training with movable armament and in siege artillery methods.*

1. At such times in the year as are most convenient lieutenant-colonels commanding will arrange to put their companies in turn through a systematic course of instruction with armament for the protection of land fronts at home or movable armament abroad.

2. Coast defence companies of the R.G.A. should be instructed in siege artillery methods by means of local courses and also courses at Lydd.

19. *Training in sheers and derricks.*

1. Instruction in the principles of sheers and derricks should form part of the garrison artilleryman's training. Every advantage should be taken of re-armament work to practise the use of sheers and derricks.

2. Should there be no re-armament work, lieutenant-colonels commanding will arrange courses in the use of sheers and derricks at such times as are suitable.

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20. *Practice.*

1. Well-conducted practice is the highest form of artillery training. Practice should be distributed throughout the year as far as possible and not be confined to special periods only.

As ammunition is limited it is necessary that the schemes for its expenditure should be drawn up so as to give the greatest possible opportunities for deriving instruction.

2. It is further necessary to see that full benefit is obtained from the practice carried out. For this purpose all records that are reasonably possible should be kept, and practice should be analysed and carefully criticized. Recorders for practice, when well trained, will not be found to interfere with the work at the guns or command posts. Lieutenant-colonels are responsible that they have a sufficient number of trained recorders available. It is the duty of all engaged in firing to facilitate the collection of records. Records of practice are of great assistance in locating faults of personnel and of *matériel*.

3. Faulty practice should be traced by analysis to its causes.

Faults, such as neglect in preparation for action resulting in sights or range-finders being out of adjustment, errors in passing orders or failure to act on them, errors in passing ranges and in giving elevation, and other similar mistakes due to personnel, will be pointed out, and the lessons pressed home at the time when the occurrences are fresh in the memory of those taking part.

Faults found in *matériel* will usually be made known to all ranks. Faults in *matériel* suspected, as the result of practice, may frequently be detected by examination of the

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gun or store without further practice. At fortress practice, in addition to the points already specified, the manner in which the tactical situation has been dealt with, the orders issued by the F.C. and B.C.'s, their wording, and the time taken in their transmission, should be discussed.

4. Much value may be derived at any practice from the criticism by the umpire (or other officer) at its conclusion. This criticism should be helpful and constructive.

The criticism should be made with the idea of imparting instruction to all concerned, and for this reason vague generalities should be avoided and the comments on essential points should be as detailed as possible. And, as all ranks learn mainly from contemplating their own mistakes, the director, without finding fault unduly, should not fail to draw attention to such mistakes, as well as to the good points of the practice.

5. A great deal of practice takes place with reduced charges. There is no great difference in the service of the gun with full and reduced charges, but the permissible errors, size of probability zones, and limits of effective fire vary considerably, and care should be taken that misleading inferences are not drawn from the results of firing with reduced charges.

6. The allotment of ammunition and the conduct of the various kinds of practice are dealt with annually in "Instructions for Practice Seawards."

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21. *Machine guns.*

1. In addition to training the personnel allotted to machine guns it is necessary to test every gun and its mounting as often as possible throughout the year.

2. The ammunition available should therefore be distributed as evenly as possible among all the machine guns.

In cases where machine guns cannot be fired from their war positions the guns should be fired elsewhere.

22. *Signalling in connection with the examination service.*

1. Signalling between the examination battery and examination vessel is to be practised periodically by day and by night.

When the examination vessel is not available for this purpose, a War Department or other vessel should be used.

2. If the examination service is under military responsibility, the semaphore for the examination vessel can be fitted to the launch used for towing targets and the regulations tested. **It is of importance that the same signallers should be used at all practices, both in the vessel and at the battery, as are allotted to the examination service for war.**

3. If the examination service is under naval responsibility arrangements should be made for periodical signalling exercises between the R.G.A. signallers of the examination battery and the signallers allotted to the examination vessel by the naval authorities.

4. Every opportunity should be taken to practise semaphore signalling, as, for instance, when a tug is used for towing targets.

5. It is of importance that the lamps used for signalling should be tested continuously for several hours once a month under adverse climatic conditions.

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CHAPTER II.

GENERAL ORGANIZATION OF A COAST FORTRESS.

23. *Organization for defence.*

1. The complete scheme of defence for a coast fortress is prepared in peace time under the direction of the Commander of Coast Defences, acting in concert with the naval authorities.

2. Every coast fortress in war will be under the command of a fortress commander, and, in the case of the larger fortresses, will, as a rule, be divided into sections, each under a section commander, who will be responsible generally for his section of defence to the fortress commander.

3. Each fortress or section of a fortress will include the portion of the garrison allotted for its defence, and the fire commands within its area. Generally speaking, the responsibility of the various arms and services for the defence of a coast fortress or defended port is as follows :—

The Royal Navy is responsible for the provision of obstructions by sea, whether temporary or permanent, such as submarine mines, booms and breakwaters.

The Royal Artillery is responsible for the guns and batteries of the fixed and movable armament, for the artillery protection of obstructions by sea, and for the tactical control of electric lights through orders issued to E.L. Directors.

The Royal Engineers are responsible for the maintenance of telephone or telegraph lines, electric lights, the

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preparation of camping grounds, water supply, land mines and defensive works.

The Infantry is responsible for the manning and fighting of machine guns, and for the protection of batteries, electric light emplacements, shore ends of booms, signal stations and cable landing places against attacks by landing parties.

In certain coast fortresses armament machine guns are manned by the Territorial Force and Special Reserve R.G.A.

24. *General chain of command.*

1. The general chain of command will run from the Fortress Commander, through Section Commanders, to F.Cs., with which latter officers the chain of Artillery Command begins. When there is no Section Commander, communication will be direct from the Fortress Commander to F.Cs. except in the case of fortresses where the artillery comprises more than one lieutenant-colonel's command, when the communication will be from the Fortress Commander through the C.R.A. to F.Cs.

The boundaries of section commands will be, as far as possible, so traced as to include entire fire commands.

All personnel and *matériel* will follow the guns, *i.e.*, officers, men and instruments will belong to the Fire Command in which their guns are situated, even when their fighting stations are topographically in another Section or Fire Command.

The general or other officer commanding Royal Artillery will act as the adviser of the Fortress Commander in artillery matters. Where the fortress is divided into sections the C.R.A. will perform such duties as the Fortress

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Commander may direct, but should usually be given command of the section which contains the most important portion of the fixed armament.

When the fortress is not divided into sections, and the artillery contains more than one lieutenant-colonel's command, the C.R.A. will issue orders to the F.Cs. in accordance with the instructions of the Fortress Commander.

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CHAPTER III.

ARTILLERY ORGANIZATION OF A COAST FORTRESS.

25. *Armament.*

1. In a coast fortress the artillery armament and the works in which it is placed are in charge of the Royal Artillery.

2. The armament mounted in permanent coast works is classified as follows :—

i. *Heavy guns* to attack armoured or unarmoured ships at long range, in order to compel any bombardment of the fortress to be carried out at extreme ranges.

ii. *High-angle fire guns* to supplement the action of heavy guns by deck attack at ranges at which the fire of heavy guns is ineffective against the side armour of attacking vessels.

Also to attack ships bombarding from positions not covered by the fire of heavy guns.

iii. *Medium guns* to attack unarmoured or lightly armoured ships. They are also for the attack of torpedo craft, and are the normal means of defence against ships whose object is to break down naval obstructions, or to block the entrance to a port or harbour.

iv. *Light Q.F. guns* intended to deal with rapidly moving and lightly armoured ships, such as submarines and torpedo craft.

v. *Guns specially designed* for attack of aircraft.

vi. *Machine guns* to assist anti-torpedo-craft guns.

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3. The guns for the protection of land fronts, and the movable armament guns, including machine guns on parapet or field carriages, will also, in some cases, be used as auxiliary to the fixed armament.

26. *Artillery scheme of defence.*

The artillery portion of the defence scheme will be prepared under the direction of the C.R.A. in conformity with the general defence scheme of the fortress commander. It will include full details on all points connected with the artillery defence, such as the siting and grouping of works and batteries, manning tables, chains of command and communications, steps to be taken to meet all possible forms of attack and the duties and responsibility of F.Cs., B.Cs., and independent G.G.Cs.

27. *Artillery chain of command.*

1. The artillery chain of command will begin with the F.C., who will be in direct communication with all his B.Cs. of heavy and medium guns, with all his G.G.Cs. of anti-torpedo-craft guns, with his advanced look-out posts, and electric light directors.

2. A high-angle battery firing over water will be included in the Fire Command in which it it most likely to be required, and will be normally under the orders of that F.C.

When required to act in another water area, the Fortress (or Section) Commander will order that the battery is to be placed under the F.C. of that water area, or to act independently if there is no F.C.

Communication must be provided between the B.C. and any F.C. under whom he is liable to be placed.

3. When a B.C.'s unit is of such a character that it cannot

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be allotted to any fire command, the B.C. must discharge the duties of F.C. in addition to his own, and he will be in direct communication with the Section Commander.

4. Battery commanders will be in direct communication with the gun groups in their command, with such P.F. instruments as may be installed for their guns, and with their fighting lights.

It may be desirable sometimes to establish direct communication between the P.Fs. and the groups they serve.

5. When gun groups are so far detached that they cannot be conveniently included in any B.C.'s unit, G.G.Cs. must execute the duties of B.C., and will be in direct communication with the F.C.

Similarly, G.Cs. may have to perform the duties of G.G.C.

6. The following general principles should be observed in the selection of positions for command posts :—

i. *The F.C.'s Post* must have a clear view of the whole of the water area over which his guns bear, combined with as extensive a view as possible of water over which vessels of any type may approach the defences. It is advantageous that the works under his command should also be clearly visible. A high site is to be preferred for the F.C.'s post so as to give an extended view seawards, and greater accuracy in the use of the range-finding and observing instrument provided for him. The staff of the F.C., for which accommodation must be provided, consists of an officer or other assistant, according to local circumstances, telephone operators, orderlies and signallers, as required locally.

An alternative post may sometimes be provided at night.

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ii. *The B.C.'s Post* must be at a spot from which he can clearly see the whole of the water over which his guns bear, and observe his fire. For the sake of efficient supervision and easy transmission of orders, it should also be in proximity to his gun groups and afford a good view of them. At the same time, in selecting a B.C. post, consideration must be given to the fact that dust and smoke caused by the discharge of the guns may obscure the target from the B.C. Similarly the enemy's fire may throw up clouds of dust, &c., near the guns. Where a D.R.F. is used it will be placed at the B.C.'s post. In the case of high-angle fire guns the B.C.'s post will be at the P.F. cell.

7. One B.C.'s post and one range-finding instrument at least will be provided for each nature of gun in a work.

8. An observing station should also be selected from which the B.C. may direct the fire of his battery in the event of his being unable to observe the fire from one of the B.C.'s posts provided. The P.F. cell, when conveniently situated, may prove a suitable place.

28. *Duties of officers.*

1. The sole criterion of a perfect artillery organization is the power exhibited by any unit, whether fire command, battery command or group, of directing upon an indicated target, at the shortest possible notice, a rapid, accurate and effective fire, and maintaining that fire until its object is secured.

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2. In all cases the main point to consider is the probable form of attack. When this has been done and the capabilities and limitations of the means of defence have been considered, the most suitable arrangements that can be devised must be determined locally.

3. *Fire commander.*—An officer detailed as F.C. must be well acquainted with the general scheme of defence for the fortress, and especially with such portion of the artillery scheme as relates to his particular command.

On taking over his duties on mobilization he becomes responsible for the efficiency, and general preparedness for war, of his entire command in every detail.

He must endeavour to make good at once any defects or deficiencies with whatever means may be at his disposal.

He must have a full knowledge of the nature and position of obstructions and of electric lights, and must be aware of the general disposition of the mobile troops protecting the rear of his command, and the detailed disposition of the troops allotted to garrison the works in his fire command.

He is entirely responsible for the fire control of all batteries and groups in his fire command by day and, to the extent laid down in para. 4, iii, by night.

In case the water area covered by any gun is not included in the field of view from his post, the F.C. will delegate the fire control of such guns to their B.C. or to the G.G.C. acting as B.C.

4. Fire control includes:—

i. *In peace time.*—The methods to be adopted under different conditions of attack, and the preparation and communication of such standing orders in connection therewith, as may be necessary, to subordinate commanders. These standing orders will include the arrangements made with other F.Cs.

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and his own B.Cs. for a suitable distribution of fire scheme by day, in order to ensure B.Cs. being able to identify their own rounds and carry out their ranging. One of the most difficult duties of a B.C. is the identification of his own rounds.

ii. *In action by day.*—Identification of the class of vessels attacking and communication of this information to B.Cs., so that fire may be opened with the most suitable projectile, and on those parts of the vessels which are most vulnerable. Selection and indication of the first and any subsequent targets to the various B.Cs. Ordering the commencement of fire (except where standing orders meet the case) and cessation of fire on any target or targets.

iii. *In action by night.*—The F.C.'s fire control at night, as regards anti-torpedo-craft guns, is exercised through the standing orders previously prepared and issued to B.Cs. and G.G.Cs., but he will in a night action, watch the action of his Fire Command and take steps, if necessary, to ensure that any heavy and medium guns available engage any blockers or boomsmashers that may appear. The F.C. during a night action will continue to control the tactical employment of the observation lights and illuminated area lights, and will give such orders as are necessary to meet any situation arising during the course of the action. (*See* Secs. 29 and 48.)

5. During an attack by torpedo craft time will not allow of targets being selected and indicated to gun-layers, and therefore a local scheme for distribution of fire must be

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worked out by the F.C. and taught to all concerned. No scheme can take into account all the circumstances that may arise, and G.G.Cs. must be prepared to act on their own responsibility, bearing in mind the general principles which govern the preparation of the scheme.

The main points with regard to any scheme of distribution of fire are that it should be simple, thoroughly well understood by all concerned, and practised as frequently as possible.

6. *Battery commander.*—With heavy and medium guns the B.C. is responsible to the F.C. for the efficiency and general preparedness for action of his guns in every detail. He will report to the F.C. any defects or deficiencies, but will endeavour to make them good at once with whatever means may be at his disposal.

In the absence of any definite orders he will be held personally responsible if he allows any enemy to pass through his fire area without engaging him. (*See* also F.S. Regs., Part 1, Sec. 12, para. 13.)

7. The range at which fire should be opened in default of definite orders from the F.C. should be laid down in standing orders, but in cases of breakdown of communication, or at times during misty weather when a hostile ship may approach unseen, the B.C. will be held personally responsible if he allows any enemy's ship to enter his fire area without engaging her.

8. By day his duty is fire direction.

Fire direction includes:—

Transmission of the necessary instructions to his command on receipt of orders from his F.C.

Ordering suitable projectiles and directing fire on his objective in accordance with standing orders.

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Opening fire on receipt of F.C.'s message, when the target is within effective range (unless ordered to engage at once), and maintaining fire as long as required by the F.C.

9. By night the B.C. is responsible for fire control in action, for the control of the fighting lights designed to serve his battery, and for fire direction.

10. The G.G.C. of light Q.F. guns has the same duties and responsibilities as the B.C. of heavy and medium guns with the exception of the control of lights.

29. *Lights.*

1. Electric lights are provided to search or illuminate areas with a view to the detection of attacking craft.

2. They may be classed in three main divisions :—

i. Observation lights, at the front limit of the defences.
ii. Fighting lights, which are moving beams allotted to serve specific guns or batteries.
iii. Illuminated area lights, so grouped as to illuminate a definite area of water.

3. Fighting lights are under the tactical control of the B.C. whose guns they serve. The remaining lights are under the tactical control of the F.C.

The F.C. or B.C. will draw up standing orders for the normal procedure to be followed as regards the tactical manipulation of these lights, and these orders will be placed in the E.L.D.'s post.

Any departure from them will be governed by verbal or other orders issued by the artillery officer in question, as the circumstances of the moment dictate.

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30. *Lettering gun groups.*

1. Each gun group will be distinguished by a letter, and each gun by its number in the group. Groups will be lettered from right to left of a work.

The following letters only will be used in lettering groups :—A, B, F, H, L, M, O, Q, R, S, U.

The letter and gun number will be painted on the breech of each gun in white on a dark ground, or black on a light ground, and also upon the expense stores, &c., which supply the group, thus $\frac{A}{1}$.

2. In the smaller fortresses groups will be lettered consecutively throughout the fortress. In the larger fortresses it may be more convenient to letter the groups consecutively through a section or fire command. Whichever system is adopted, each group in a fire command will be lettered differently.

3. For fighting purposes, anti-torpedo craft guns may be numbered and lettered at the discretion of the C.C.D. in accordance with the local scheme for distribution of fire.

31. *Storage of ammunition.*

1. The mode of storage of ammunition varies in different forts, according to their nature, size, &c.

There are usually, however :—

Cartridge and shell recesses, for immediate supply to the guns.

Magazines and filled shell stores, from which such recesses can be replenished.

Cartridge and shell recesses are provided in all modern works in the immediate vicinity of the guns.

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2. Cartridges must be placed in the magazine in groups according to "lots." In war the largest group, or that for which special range strips have been prepared, are to be used first, and should therefore be stored nearest the issuing hatch in such a way as to facilitate immediate issue.

Care must be taken that each gun of a group uses the same "lot" of cartridge, and, in cases where guns of a group are served by separate magazines, the "lot" of cartridge will be divided equally between such magazines.

3. Magazines must be dry and well ventilated.

With a view to the magazines being open as long as possible on favourable days, the wet and dry bulb thermometers should be observed twice a day, morning and afternoon, and the readings recorded in A.F. G 944. A record will also be kept of the readings of the thermometer inside the magazine. These records will be hung up in each magazine and signed weekly by the officer in charge.

4. Class A magazines, *i.e.*, those the walls of which are exposed to the outer air on all sides, should be ventilated whenever the weather is fine, but should the temperature of the outside air be over 40 degrees there must be a difference of 3 degrees or more between the wet and dry bulbs.

5. Class B magazines, *i.e.*, those any wall of which is not exposed to the outer air, should be opened for ventilation when the reading of the thermometer inside the magazine is higher than the reading of the *wet* bulb thermometer outside.

6. Great care must be taken that the magazine is securely closed as soon as the above conditions cease to apply, or when that point is approached.

7. Shell are always stored filled in the shell stores.

8. Shell should be grouped into three main groups by

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weight, sub-grouping by nature, mark and date, to ensure that change from one group to another will entail as small changes in ballistics as possible, and to comply with the Regulations for Magazines.

The shell it is intended to employ first in war must be stored in such a way as to facilitate immediate issue.

9. All B.L. and Q.F. filled shell (except those stored in boxes) will be stored on their bases unless, for local reasons, it is found necessary to pile them.

10. The grummets on B.L. and Q.F. projectiles fitted with the "driving band with gas check" will be kept on the projectile when in store and R.A. charge, and under ordinary circumstances will not be removed until the projectiles are required for the service of the gun.

11. Shells fuzed with base fuzes will never be placed, either temporarily or permanently, with the point of one against the base of another.

12. To preserve the paint on projectiles stored under cover, they will be coated with boiled linseed oil when necessary.

In the case of lyddite shells, linseed oil, as supplied from Woolwich only, will be used.

13. Case shot should be stored as near to the guns as circumstances permit.

14. Tubes and fuzes are kept in fuze and tube stores, or shell stores.

It is most important that the store in which tubes and fuzes are kept should be a dry one, as, unless protected from damp, they will quickly deteriorate.

Tubes must be kept in groups according to date of manufacture or repair, and fuzes in groups according to "lot" or date of repair or conversion.

15. Particular attention must be paid by those in charge of ammunition to the magazine regulations regarding :—

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Classification of explosives.
Magazine conditions.
Precautions against fire.
Ventilation.
Lighting.
Laboratory operations.
Disposal of missfires.

32. *Supply of ammunition.*

1. The arrangement for the supply of ammunition must be such that no check is likely to occur. This can only be ensured if there is a large supply of ammunition in the immediate proximity of the gun.

Consequently, where there is insufficient storage in recesses, temporary depôts for cartridges and projectiles should be arranged in the most sheltered places on the level of the gun emplacements, and supply should be made from these depôts direct to the guns.

The positions for these depôts and the number of rounds that can be accommodated will be inserted in the Fort Record Book.

2. The number of rounds to be held in readiness per gun in depôts must be determined from consideration of the rate of fire of the gun and the probable duration of its period of action as governed by local circumstances, and also depends on whether recesses are provided. In general, sufficient ammunition should be contained in recesses or depôts to enable the gun to be supplied from them for any period for which it is likely to be continuously engaged.

3. With regard to light Q.F. guns, probably the greatest rate of aimed fire which can be attained with the 12-pr. Q.F. is 20 rounds per gun per minute. Assuming the illuminated area to extend for 1,000 yards, this distance allows one minute

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and a half for torpedo craft to be under fire when attacking at 20 knots. As it is possible that all the torpedo craft may not enter simultaneously, it will be well to allow that, during an attack, each gun may be required to fire for six minutes practically continuously.

This entails the expenditure of 120 rounds. Time will not be available to supply them from magazines or stores when the action has commenced; arrangements must, therefore, be made beforehand by provision of temporary depôts, to accommodate about 130 rounds per gun in close proximity to the mountings. Of this ammunition, sufficient should be at once available for one minute's firing; that is, lids of boxes should be unscrewed and covers removed; the lids of the remaining boxes should be unscrewed, but the covers will not be removed until the guns are manned for action.

4. Shell recesses and depôts will be filled with fuzed shell when hostilities appear imminent; the O.C. the sub-district will be responsible that this is done. On mobilization the B.C. will be responsible for the further supply.

The refilling of recesses and depôts from magazines or stores will proceed at once on the conclusion of an action, or during a temporary pause.

5. Replenishing the depôts and the recesses is the duty of the ammunition detail, shell being fuzed either before they are brought up, or on the gun floor, as may be determined locally.

6. The normal supply of ammunition is from recesses or depôts, these being replenished from magazines and shell stores as opportunity offers. But it may sometimes be advisable to use lift supply direct to the guns at the beginning of an action, when fire is deliberate and the men are fresh and have not been reduced in numbers by casualties, and to reserve the supply in recesses and depôts till a later

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period, when a more rapid rate of fire will be required, the detachments will probably be working with reduced numbers, and the men will have begun to tire.

7. The supply of cartridges and projectiles from temporary depôts to the gun is the duty of the ammunition numbers of the gun detachment.

Where the stores are on the same level as the gun emplacement the track for barrows should be made as direct and as easy as possible.

Where they are below, and ammunition has to be sent up by the lifts, the lifts should be marked, both above and below, with the group letters and numbers of the guns which they serve. The route of the ammunition from the stores to the foot of the lifts should be clearly indicated, and speaking tubes may have to be provided from the top to the lower level.

8. Careful arrangements must be made to enable a change from one nature of shell to another to be rapidly carried out when required. This is especially necessary with the 9·2-inch gun on Mark V mounting, with which delay might be caused by all the trollies being filled at such a time with the wrong nature of projectiles.

9. With Q.F. guns a proportion of the ammunition must be prepared with adapters fitted for percussion firing, and the necessary tubes must be kept in readiness on the gun floor.

10. The duties of the ammunition numbers in detachments of Q.F. guns will consist in opening cartridge boxes, supplying the gun numbers with cartridges and projectiles, and removing empty cases. During any cessation of fire all hands, except look-outs, should at once proceed to assist the ammunition detail, whose duty it is to refill the temporary depôts and remove empty boxes, empty cases and débris.

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33. *Lighting of works.*

1. Means will be provided for illuminating all works to enable the guns to be fought at night when necessary. The only satisfactory way of doing so is by electricity, as any kind of oil lamp is liable to be extinguished by the concussion caused by firing.

2. Great care is to be exercised to prevent any lights in a fort showing seawards.

3. Advanced works which, owing to the siting of the guns, position of P.F. cells, &c., may offer well-defined marks for the enemy's guns, should be lighted up with caution. Experiments in each locality can alone determine the extent to which lighting can be safely carried out, and the best means to be adopted to screen the lights so as to prevent the identification of the works. It should be remembered, however, that it is of great importance that sufficient lighting should be provided to allow of a rapid and efficient service of the guns.

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CHAPTER IV.

MANNING AND FIGHTING GUNS BY DAY.

34. *Manning a battery command.*

1. The following instructions will be adhered to in their entirety only for instructional purposes, or when a unit is unfamiliar with the work. When a company is called upon to man for action a work with which it is familiar, it should fall in on the manning parade only for purposes of inspection and for the issue of such instructions as are absolutely necessary.

The normal method of working should be the subject of standing orders.

2. The manning table of a work shows the personnel required. Officers and men should be told off to their various duties in action before arrival at the work.

On arrival, all details will be formed up on the manning parade in column by the left, B.C.'s staff in front, then the group details and ammunition party, and the reserve in rear, as shown on the manning board.

The P.F. details and permanent establishment will not fall in on the manning parade. The latter should have all doors unlocked, lamps lighted, and stores ready for issue by the time the group details arrive at the work.

The P.F. specialists will parade at their stations in sufficient time to have all ready at the hour named. As soon as the instruments are correctly prepared for action, they will report to the B.C.

The senior N.C.O. of the B.C.'s staff will check his men,

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and ascertain that each knows his duty, and where he has to go; he will then stand them at ease and report "All present and correct" to the B.C.; he will then fall in again two paces from the centre of his command on the inner flank.

The G.G.Cs., after seeing that the detachments are correctly told off, will stand their groups at ease and report to the B.C. "..... Group, all present and correct," and fall in again two paces from the centre of their commands on the inner flank.

When the B.C. has received the above reports from the commanders of details he will call the parade to "Attention," and give such instructions as he considers necessary, regarding, for example :—

Nature and supply of ammunition.
Means of range-finding and position of instrument.
Means of passing ranges, orders and corrections.
Case and means of laying.
} Alternative means to be used in case of damage or breakdown may be detailed.
Method of fire.
Means of observation.
Replacement of casualties.
Position of B.C.

35. *Preparation for action.*

1. The B.C. will then order "Prepare for Action."

On this Order :—

The B.C.'s staff will double away and bring up their stores going straight to their various places in action.

The ammunition party will go to their posts in action.

2. *B.C.'s Duties.*—If time permits, the B.C. will make a n

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inspection of all sources of ammunition supply, and see that his men are properly posted and know which ammunition to issue, and in what order; that all appliances (lifts, &c.) are in working order, and lamps ready to light (or lighted, if required); and that the Regulations for Magazines are carried out.

3. The B.C., on arriving at his command post, will satisfy himself that his communications are in working order, charts, &c., ready to hand, and that the range-finding instruments are properly set up and ready for use.

He will ascertain the alteration from range table or calibration M.V. due to wear, and if information is available the M.V. to be expected from the lot of cordite in use; also the readings of barometer and thermometer, the strength and direction of the wind, and the state of tide. From these data he will work out and summarise the day's initial correction for several ranges so that when a target appears it will be only necessary to add further corrections for travel and point of impact. He must bear in mind that some of these conditions, such as wind and tide, will vary from time to time, and that all of them may do so. He must, therefore, be prepared to modify the original correction.

4. When time admits, he will await the report "Ready for action" or "Ready to load" from his subordinates, and will then make an inspection of the groups, ammunition stores, &c., otherwise he will make this inspection as opportunity offers at any time before, or during pauses in, action.

This inspection is a very important part of a B.C.'s duty and should be as thorough as possible. Each individual, from the G.G.Cs. downwards, should be questioned in turn, not only as to what he has done during preparation for action, but also as to any special duties he may have to perform during action. Leading questions, *e.g.*, those to

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which the answer is "Yes" or "No," should be avoided and the B.C. should satisfy himself, both by enquiry and by personal observation, that his guns are in every respect ready for action and that all possible contingencies have been foreseen and provided for.

5. When the B.C. is satisfied that his Command is ready in all respects he will report to the F.C.

The B.C. will post one man as a look-out at the B.C. post, and the whole of the manning detail, if allowed to fall out, must hold themselves in readiness to fall in at once in their places in action on the "alarm" sounding.

6. *G.G.C.'s Duties.*—The G.G.C. will march the details to the groups they are to man, and, on arriving at the guns, will order "On your guns." On this command the G.C. will form up his detachment in rear of the gun he is to man, facing the front.

When each G.G.C. is satisfied that the detachments are in their places, he will order "..... Group, Prepare for action." (*See* Sec. **53**).

When details are familiar with the work, the G.G.C. may order "..... Group, Prepare for action," before leaving the manning parade, when the G.C. will at once take charge and prepare for action.

7. The G.G.C. is responsible to the B.C. that his group and all details and stores connected with it are efficient and fit for action.

In action he will always be with his group, and is responsible for discipline in it, and for the quick, quiet, and efficient service of his guns.

He will ensure that the ammunition required for the immediate service of his guns is always ready to hand, and that the ammunition numbers understand the grouping of cartridges and projectiles.

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No gun of his group will be fired without his order, except at gun fire.

8. He has, normally, nothing to do with selecting the method of fire, projectile or target, or with ordering the commencement of fire. But, in case of damage to range-finding instruments, or failure of the ordinary communications with the B.C., he must not hesitate to take upon himself the responsibility for independent action in these matters.

In the case of any casualty to personnel or *matériel* he will at once take steps to replace or remedy it; he will only report to the B.C. when a casualty occurs which he is unable to replace, and which will place a portion of his group out of action.

9. He will supervise the preparation for action of his group as described in Drill Handbooks and "Manual of Coast Defence Range Finding."

He will pay particular attention to the disposal of group stores, spare parts, and implements.

10. During preparation for action, or when the guns are reported "Bore clear, Ready to load" by the G.C.s, he will make a thorough inspection of his group gun by gun.

He will make sure that his G.C.s thoroughly understand the case of laying, means of passing ranges and giving elevation, source of ammunition supply, &c., to be used, and the method of replacing casualties.

He will see that gun differences and corrections for tilt are correctly marked on the gun floor, mounting, or curtain.

11. He will see that the arc over which the blast of any gun interferes with neighbouring guns is marked by a danger patch on the gun floor, safety stops, or other means.

12. He will tell off men to remove sights and locks or strikers in the event of the battery being rushed by a raiding party.

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13. In default of orders to the contrary from the B.C. the G.G.C. will then give the order to load with the nature of projectile previously ordered by the B.C.

As soon as the guns are loaded, G.G.Cs. will give the order "Make safe" to their groups.

The G.G.C. will then report to the B.C. "..... Group, Ready to load" or "Ready for action," as the case may be.

36. *Methods of fire.*

1. There are two methods of fire—

Battery fire.
Gun fire.

2. *Battery fire*—

i. In Battery fire the guns are fired in succession throughout the battery from the right at 3 seconds interval, unless otherwise ordered.

The number of rounds per gun to be fired will be ordered, by the Battery Commander, *e.g.*,

"One round battery fire."
"Two rounds battery fire, 5 seconds."

ii. The Battery Commander may order any interval, but should he require sufficient interval between rounds to observe and correct, the order will be "Battery fire by order," when guns will be fired singly on the order "Shot," or on a pre-arranged signal from him.

iii. In no case will fire be delayed on account of a gun not being ready. If necessary, the G.G.C. will inform the G.G.C. of the adjoining group that he has a gun, or guns, out of action.

iv. Battery fire is suitable for ranging, or may be used when the B.C. wishes a steady succession of fire without too great an expenditure of ammunition. At Battery fire, the guns are fired by order of the G.G.C

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3. *Gun fire—*

i. Guns are fired independently and as rapidly as possible under the supervision of the Gun Captain.

Should the B.C. consider it desirable, he may order the number of rounds per gun to be fired, *e.g.*,

"Three rounds gun fire."

ii. Gun fire is the normal method of fire when guns have been ranged, and may be suitable for ranging calibrated guns at medium ranges.

At Gun fire, the guns are fired when ready.

37. *Means of passing orders.*

1. The telephone will be used for conveying orders from the F.C. to his B.Cs. Signalling arrangements should be organized to take its place in case of breakdown.

2. Orders from a B.C. to his G.G.Cs. will be passed by megaphone, order dials, speaking tubes or painted plates as determined locally. In some cases, as for instance with H.A.F. guns, the telephone must be employed; this means would almost always be used for conveying orders over comparatively long distances.

3. In some batteries it may be more convenient to transmit orders by displaying numbers on a black board or other similar means; each number signifying some definite order in accordance with a pre-arranged code.

4. Orders as to the method of fire to be employed may be given by displaying, at the B.C.'s post, the following code of numbers :—

(1) Battery fire.
(2) Battery fire by order.
(3) Gun fire.

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5. Orders as to deflection may be given by displaying, at the B.C.'s post, plates for each group with figures and letter R or L painted white on a black ground. If the range indicator is in use these plates may be hung on the frame below the dial face.

6. It is often advisable to call the attention of G.G.Cs. and others concerned to any order or change of orders by means of the whistle. This is especially the case when code numbers or painted plates are used to convey orders.

7. The importance of passing orders correctly cannot be exaggerated, and B.Cs. must arrange that the receipt of an order is always definitely acknowledged by the G.G.C. If the G.G.C. can see the B.C. he should acknowledge by saluting ; if he cannot, some other method must be arranged, but the B.C. must never be left in doubt as to whether his order has been received.

Similarly, G.G.Cs. must arrange for the correct receipt of their orders, which should always be acknowledged.

38. *Bugle sounds.*

Where bugle sounds are used in fighting guns, the undermentioned calls will have the signification stated against each.

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"Trumpet and Bugle Sounds." Name of Call.	Signification
Alarm	Immediate manning of all guns and stores, each officer and man going direct to his station in "Action."
Double	"*Action*," work to be proceeded with.
Continue	Firing to commence, or to be re-commenced, when it has been stopped by order "*Cease fire*," or by bugle sound "*Stand fast.*"
Stand fast	Detachments and various details cease their work and remain in their then positions.
One "G"	To call attention to an order, or change.

39. *Whistle sounds.*

1. Every B.C. and G.G.C. must be provided with a whistle. The whistle will not be used by any officer other than the B.C., or, at light Q.F. guns, the G.G.C., unless authorized by them.

2. The use of the whistle will be as follows:—

One blast will signify a momentary cessation of fire to enable orders to be heard, or to call attention to an order, and, with this exception, the service of the guns will proceed as usual, the G.L. following his target. Fire will be con-

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tinued immediately orders have been received and acted on, unless "Stand fast" or "Cease firing" is given.

40. *Battery drill.*

1. It is assumed that the work has been manned and prepared for action, that the B.C. has worked out initial corrections for the conditions of the day, and that the detachments have been allowed to fall out, leaving one man in charge of each group.

2. The F.C. has warned the B.C. by a message such as the following :—

"Hostile squadron sighted 20 miles N.E."

On receipt of this message the Battery Commander will order the "Alarm" to be sounded. The whole of the manning detail will immediately double to their places in action ; gun detachments will be ordered under cover by the G.G.Cs.

The next order received from the F.C. will probably be :— "Class..... Square ....."

This is an order to the B.C. to engage the ship indicated when she arrives at a suitable range. He therefore identifies the ship from her position, ascertaining from his fighting book the most suitable projectile to employ and the range at which to open fire. Subject to the receipt from the F.C. of subsequent orders as to change of target or cessation of fire, the whole conduct of the action from this point, as regards his own battery, is in his hands.

3. The B.C., on receiving the above order, will point out the target to his range takers and G.G.Cs., informing them at what range he intends to open fire.

In case of doubt he may himself direct the range finder on the target, to ensure that it is identified correctly.

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The B.C. will also give orders regarding projectiles, means of laying, method of fire, and any other points which may have been undetermined.

All orders passed by word of mouth to the G.G.Cs. will be repeated by them, and acknowledged by saluting.

4. The B.C. will then complete his calculations and order the initial deflection and range corrections to the groups, also gun corrections to individual guns if necessary.

5. Deflection will be "cumulative," and will be ordered as "... Group (or ... Gun) ... minutes more right (or left)." The method of passing deflection will form part of the local scheme of communication of orders. When deflection is ordered by the G.G.C., the amount ordered will be repeated by the number setting the sight or traversing pointer, to show that the order has been correctly stated. It is generally advisable when using painted plates or some similar device to draw attention to change by one blast of the whistle.

6. Under certain circumstances it may be desirable to order the G.G.Cs. of certain groups to correct their fire for line.

7. Range corrections will be "cumulative," that is, the corrections ordered will be added to, or taken away from, the amount of the corrections already ordered. They will be given as "lengthen.....hundred" or "shorten..... hundred."

8. When ranges are found by P.F., G.G.Cs. will be responsible that the corrections are properly applied to the movable-faced dials.

When a large correction has to be applied at a gun, it may be necessary to split it, round numbers of hundreds of yards being applied by the gun layer, the balance being put on the movable face of the dial by the setter.

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In the case of a large initial correction, the B.C. may order the P.F. operator to make the correction, or part of it, at the instrument.

This plan will not generally be advisable for subsequent corrections, except when the B.C.'s post is at the P.F. cell, as in the case of H.A.F. guns.

9. With D.R.F., if a separate mechanical dial or range indicator is provided at the B.C.'s post for each group, B.C.'s corrections will be applied to the ranges before they are transmitted to the groups.

If one mechanical dial works the dials of more than one group, the G.G.Cs. will be responsible that the corrections are applied to the movable-faced dials.

If one range indicator only is available at the B.C.'s post, G.G.Cs. will be responsible that the group-dial numbers keep the proper difference between their dials and the B.C.'s dial, corrections being ordered to the groups.

10. When fire direction has been delegated to a G.G.C., he will order his corrections to be applied as indicated above.

11. Range indicators should, if possible, be placed in view of the setters for range, so that they may read the range direct from the dial and apply it to the sights or call it to the layer at the elevation indicator.

12. The B.C. should always employ one of his staff to keep a record of his observation and of the corrections ordered, so that in the event of the B.C. becoming a casualty, the officer replacing him shall find recorded all necessary information regarding ranging.

These records should show both the cumulative corrections ordered by the B.C. and their net effect on the range.

13. As soon as the target is pointed out, range takers will

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follow the target; with P.F. or with mechanical dials they will keep LAY down.

Range indicators will not take up the range until ordered.

14 G.G.Cs., on receiving orders as to target, will call up their G.Cs. and layers and point it out to them. It may be desirable for the G.G.C. to align a gun on the target himself, causing the G.Cs. and layers to identify the vessel over the sights

G.G.Cs. will then order the layers and setters to take post and follow the target, the remaining numbers being kept under cover.

15. Shortly before the target arrives at the range at which he desires to open fire the B.C. will order "Action" or sound the "Double." On this command operators and dial numbers will turn LAY up and range indicators will pass ranges.

On "Double" sounding, LAY appearing, or when range indicators begin to pass ranges, group dial numbers or setters for range will call "Lay" and proceed to call ranges at 25's, 50's or 100's as may be ordered. (At Case I setters for range will set the sights instead of calling ranges.) G.G.Cs. will order "Action" to their groups.

16. For the sake of uniformity drum readers and group dial numbers will call ranges as in the following example :—

10250	Ten two fifty.
3100	Three one hundred.
3050	Three nought fifty.
3000	Three thousand.
2950	Two nine fifty.
2900	Two nine hundred.
1850	One eight fifty.

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17. When the target arrives at the range at which fire is to be opened the B.C. will sound "Continue" or order "Commence firing" or he will order or signal "Shot."

"Continue" will always be sounded, or "Commence firing" or "Shot" will be ordered, before fire is opened from a work, and also before fire is recommenced after "Stand fast" has been sounded or "Make safe" has been ordered.

When changing from one method of fire to another the new method will be taken up at once, and no new order "Commence firing" will be given.

18. At Battery fire, the G.G.C. will order his guns to fire by giving the order "Fire A/1," "Fire A/2," &c., in time to maintain the proper interval. The order to fire will not be given to a gun which is not loaded and run up.

19. Should the B.C. desire to suspend the fire temporarily he may order "No range," when mechanical dial numbers will turn LAY down, and range indicator numbers will stand in front of their dials.

On the order "Pass ranges" mechanical dial numbers will turn LAY up and range indicator numbers stand clear.

At the group, on LAY disappearing or on B.C.'s dial becoming obscured, the dial number or, in the case of dials on mountings, the setter for range, will call "No range," and with range indicator stand in front of his dial.

On LAY re-appearing, or B.C.'s dial number standing clear, the group dial number or setter for range will call "Lay" and continue to pass ranges.

20. Should dials cease moving while LAY is showing, the fact will be reported to the B.C.

21. When the B.C. is satisfied that he has obtained the proper correction for his groups he will generally order

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"Gun fire." When one or more groups in the battery command require ranging separately, the B.C., having completed the ranging of one group, may order "Gun fire" for it, keeping those of which the ranging is not yet complete at battery fire.

Should the B.C. desire to stop firing at any particular target, and at the same time to have his guns empty so that he may load with any description of projectile, he will give the command "Empty guns." Each gun will then be fired as soon as it is correctly laid, and not reloaded.

22. When the B.C. orders "Stand fast" or "Under cover" he will, if he considers it desirable, inform his P.F. operators, who should take that opportunity to rest their eyes by ceasing to follow the target.

23. If the B.C. is employing Gun fire when the target reaches auto-sight range, and if a change to auto-sights is necessary, it is desirable that the change should be made without alteration of the method of fire, for it is at medium ranges that the greatest effect is to be expected, and therefore the method of fire should be that which will give the greatest rapidity.

On the other hand, it may be found that the corrections for auto-sights cannot be determined at Gun fire; it will then be desirable to order "Auto-sights" and "Battery fire" to one group at a time until it has found its corrections, allowing the remainder to carry on with Gun fire.

24. It is undesirable to change from one method of laying to another during action when good results are being obtained; and as a rule a change from Case II to auto-sights under such circumstances would be justified only by serious casualties to the range-finding instruments or means of passing ranges.

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A change from one means of range-finding to another or to auto-sights may sometimes be necessitated by the target entering an area not covered by the P.F. or D.R.F.

If the B.C. wishes to change from one method of laying or means of range-finding to another during an action, such change must be carried out without any delay or check in the rate of fire and, in most cases, without any cautionary order being necessary. When such a change has to be made, advantage should be taken of ranging already done.

25. In order to prepare for a change to auto-sights, tide levers will be kept correctly set by order of the G.G.Cs. and during the action, as soon as the target comes somewhere near the effective limit of the auto-sight (App. II, Sec. 18), the auto-sight layer will bring his pointer on to the water-line of the target from time to time, by manipulating the error of the day drum as "on" is called by the layer for elevation.

In this manner the necessary correction should have been applied to the auto-sight, and on the command "Auto-sights" from B.C. the pistol grip will be shifted and the auto-sight layer will carry on at the auto-sight.

26. With guns fitted with combined auto- and rocking bar-sights the change may be made on similar principles as follows :—

On the command "Auto-sights," the gun being properly laid at correct range, the G.L. will engage the latch of the auto-sight, if necessary bringing it opposite the fork by means of the hand wheel of the sight. He will then bring the telescope pointer on to the water-line of the target by means of the error-of-day drum (which has up to now been unclamped) and clamp the drum. Subsequent ranging should not involve any great change of correction thus obtained. A pause should be made in the loading while the

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change is being effected so as to avoid altering the elevation of the gun.

27. A change from Case II to Case I is unlikely but, should it be necessitated by a breakdown of the elevation indicator, the B.C. of a high sited battery must remember that an increase to his range correction at short to medium ranges will be required at the gun affected, since range corrections at Case I take effect along the line of sight.

28. As regards training, as a preparation for a change to Case III, the movable face of the dial will be adjusted so as to make the training on the gun and dial agree at the moment of firing. By this means allowance is automatically made for convergence and drift.

29. To change from Case III to another method of laying, so long as the P.F. dial is giving trainings, sights can be brought on the vessel's bow by shifting the deflection leaves at the moment of firing before making the change. If the change is necessitated by a casualty to the P.F. or dials, this method cannot be employed (except at a stationary target) and the deflection on the traversing pointer must be ordered for the sights.

30. As regards range-finding instruments, if the P.F. and D.R.F. are in proper adjustment and have been made to agree with one another when last on the datum and the dials serving the two instruments have been taking up the B.C.'s corrections properly, there should be no discrepancy, or a very small one, between the P.F. dials and the range indicator. Any discrepancy there may be should be taken up as a gun correction when changing from one means of range-finding to another.

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41. *Replacement of casualties.*

Casualties will be replaced as follows until further arrangements can be made :—

i. The B.C. will be replaced by the senior G.G.C. in his command.

ii. Casualties among the B.C.'s staff will be replaced from the reserve. At the commencement of action the reserve will generally be employed with the ammunition detail in replacing ammunition expended from cartridge and shell recesses.

iii. A G.G.C. will be replaced by the senior G.C. in the group.

iv. G.Cs., G.Ls., setters and loading numbers should be replaced by named successors, who will generally be employed in the detachments among the higher numbers supplying ammunition under cover.

v. Casualties in detachments on service would, whenever possible, be made good from the reserves or from the detachments of other guns that might not be in action at the same time. but in most cases it will be necessary to carry on with reduced numbers.

vi. When casualties are excessive and cannot be replaced, intensity of fire will often be better maintained by reducing the number of guns in action, so as to enable the service of the remainder to be more efficiently carried out, especially if ammunition depôts and recesses have become exhausted.

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42. *Conclusion of action.*

The B.C. will collect reports as to casualties and expenditure of ammunition for the information of the F.C.

When "Cease firing, replace stores" is ordered, all details will replace their stores and fall in in their places on the manning parade.

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CHAPTER V.

MANNING AND FIGHTING GUNS BY NIGHT.

43. *General instructions.*

1. The personnel for guns fought at night must be on the alert, in all weathers by night, and in thick weather by day, and ready to fight their guns at short notice.

Under the most favourable circumstances warning of attack cannot be expected to reach them more than a few minutes before they are required to open fire.

Under less favourable circumstances the first warning may be the appearance of hostile craft in the illuminated area.

Targets will probably be numerous, speedy, under fire for a very short time and perhaps only dimly visible.

It is clear, therefore, that officers and men must be particularly efficient and that special training and organization are necessary.

2. The probable conditions under which a night attack will take place are as follows :—

i. Vessels may not be sufficiently visible to allow of aimed fire being directed at them until they enter the illuminated area.

ii. Vessels will always endeavour to pass through the illuminated area as rapidly as possible.

iii. Once through this area they are tolerably safe from the fire of the guns protecting the area.

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3. The form of attack may vary considerably.

i. It may be made by different classes of vessels simultaneously or consecutively.

ii. It may be made by a number of vessels of the same class simultaneously or consecutively, in pairs or in groups, at regular or irregular intervals.

iii. It may be made by single vessels.

4. The arrangements made, therefore, to meet night attacks must admit of:—

i. **A rapid and accurate fire being opened at a moment's notice.**

ii. **Efficient distribution of fire.**

iii. **A suitable division of the manning detail into watches and the provision of accommodation for those watches.**

44. *Preparation for action.*

1. Preparation for action will be carried out on the principles detailed in Sec. **35.**

2. Although guns have always in war to be kept ready for action, preparation for action will be carried out daily, in order to prevent defects remaining unnoticed, which may occur after the first preparation for action. This is best carried out an hour before sunset, and should be done one gun at a time.

3. Spare parts should be fitted occasionally, but to avoid guns being out of action if required at short notice this should be done gun by gun, and never at night or in thick weather.

4. Lamps should be lighted half-an-hour before dark.

5. Guns may be kept loaded by day if it is thought desirable, but they must always be so at night and during

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thick weather, the breech blocks being left open, except during heavy rain. The guns should be kept laid in the direction from which attack is to be expected, at a suitable elevation within the limits of auto-sight range, to cover the water area over which an attack is probable.

6. G.G.Cs. will ensure that the men of each watch understand the scheme for distribution of fire, the method of ammunition supply and of replacing casualties.

45. *Watches.*

1. Anti-torpedo-craft guns will be effectively manned during the hours of darkness and in thick weather. By this is meant that sufficient men must be ready for instant action in the immediate vicinity of the guns to open and maintain fire until such time as the complete manning detail can arrive to reinforce them.

2. For this purpose the whole manning detail, including ammunition numbers, spare men, &c., allotted to a group of anti-torpedo-craft guns, will be divided into two watches. These watches will be alternately on duty and in reserve during the hours of darkness.

3. Gun floor shelters are provided in the immediate vicinity of all guns which are manned at night, except the 9·2-inch gun. The watch on duty will be quartered in the gun floor shelters near the guns, and must always be ready for instant action.

These shelters are to be kept lighted and ventilated, and every effort made to ensure the comfort of the men accommodated in them.

Except in stations where the climate renders it unnecessary arrangements will be made for warming the shelters.

4. The watch on duty is not allowed to sleep or lie down,

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but sitting accommodation with tables and chairs should be provided.

Smoking, reading, &c., should usually be allowed in these shelters. On the alarm being given the watch on duty will at once man the guns.

5. The watch in reserve will be quartered as close to the guns as possible, according to the temporary or permanent accommodation available. The watch in reserve should be provided with lying down accommodation and it is most important that any watch while in reserve should get as much rest and sleep as possible.

If the gun floor shelters are capable of holding both watches the personnel may be so accommodated, but in this case some partition must be erected to divide the watch on duty from the watch in reserve in order that the latter may sleep.

Arrangements will be made to communicate the "alarm" at once to the watch in reserve, who will reinforce the watch on duty.

6. The manning detail allowed will usually enable each watch to contain enough men to open and maintain an effective fire until the other watch arrives.

The maximum numbers required to maintain such fire are approximately 6-inch, 9 ; 4·7-inch, 7 ; 4-inch, 6 ; 12-pr., 5, but these numbers can often be reduced and the actual numbers must be settled locally, the object aimed at being to avoid keeping more men awake than is necessary.

7. **In cases where extra detachments are allowed, or where numbers permit, it may be found advisable to divide the manning detail into three watches.**

8. An officer should, if possible, be detailed for each watch. If sufficient officers are not available a serjeant will be placed in charge.

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Where two groups are sited close together arrangements may be made for one officer to be placed in charge of both watches on duty and another officer in charge of both watches in reserve.

46. *Relief of watches.*

1 In making arrangements for the relief of the watch the following principles will be followed :—

i. The watch on duty must be ready for instant action at all times. Its period of duty should not, therefore, be extended beyond the number of hours during which men may reasonably be expected to remain on the alert.

ii. At the same time short periods on and off duty, entailing frequent change of watches, are very trying to the personnel during a prolonged mobilization, and under certain conditions a comparatively long period on duty followed by a similar period of rest may impose less strain on the personnel in the long run.

iii. When the nights are short it may be possible to keep one watch on duty the whole night, the watch in reserve thus obtaining a complete night's rest.

iv. When the nights are long the number of times the watch on duty should be relieved will depend on the time of the year and on local circumstances, such as the climate, the physical condition and efficiency of the manning personnel and the quality of the accommodation in the gun floor shelters.

v. The watch on duty should seldom remain on duty for a less period than four hours ; the maximum time must depend on local circumstances.

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vi. When there is more than one group in a work the watches belonging to the various groups will not be relieved simultaneously, but consecutively.

2. It is for the officer commanding each work to draw up a suitable time-table in accordance with the above principles, showing when the watches are to be relieved. He will also arrange suitable reliefs for telephonists.

3. Officers commanding groups will make arrangements for their men to get a proper allowance of sleep during the day.

4. At night mannings the relief of the watch should be practised. This should be done even though the night manning only lasts a few hours.

47. *Gun look-outs.*

1. Gun look-outs will be posted at night and during thick weather. They will be furnished by the watch on duty at a rate of one per gun with a minimum of two per group.

2. Each gun look-out will be posted on the gun floor of his own gun, and will be on duty for one hour. Look-outs of a group will be relieved alternately every half hour, thus ensuring continuity of observation. The gun group commander may post additional look-outs elsewhere, should he consider circumstances demand it.

3. The gun look-outs will keep a continuous and sharp look-out, and will, if necessary, be provided with field glasses. They will set the tide levers as follows :—

(*a*) Time tide tables.—Set tide lever to what tide will be in a quarter of an hour's time.

(*b*) Tide gauges.—Set tide lever half a foot ahead of the tide.

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When relieving look-outs, the officer (or non-commissioned officer) in charge of the watch on duty will satisfy himself that this has been done.

4. The action of the look-outs on the approach of any vessel is laid down in Sec. 48, 1.

5. The officer (or non-commissioned officer) in charge of the watch on duty will ascertain personally that the look-out sentries on the guns are thoroughly familiar with their duties.

When watches are being changed the gun look-outs of the old watch will remain on look-out duty until the gun look-outs of the new watch are accustomed to the searchlight.

6. Detachments should include as many layers as possible as the gun look-outs may have to fire the first round.

48. *Fire control*

1. The B.C. of a night battery or the G.G.C. of an A.T.C. group is responsible for opening fire. As there is always the possibility of torpedo craft eluding the advanced look-out and entering the illuminated area before warning has reached the groups, the gun look-outs will be ordered to open fire on any vessel that may appear in the illuminated area, without waiting for the detachments to turn out; but should the officer (or N.C.O.) in charge of the watch on duty be present on the gun the look-out will take *his* orders before firing.

2. While it is absolutely necessary to prevent any chance of a hostile vessel slipping past without being engaged, the inconvenience that would be caused by a false alarm must be impressed on all concerned.

3. The F.C. is responsible that subordinate commanders have clear and definite general instructions as to the class of vessels, limits of range, &c., at which fire is to be opened, in order to guide them in coming to a

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decision ; and that they receive early and clear information as to any friendly vessels that are permitted to enter the waters and the marks by which they are to be identified. (Sec. 28, 4, iii.)

49. *Fire direction.*

1. Anti-torpedo-craft guns will normally be fought by gun fire using auto sights.

2. The initial corrections for range and line will be ordered by the G.G.C. During action the layers will work independently, observing and correcting their line, and, under exceptional circumstances, their elevation, calling out their corrections to the setters, who place them on the sights by blind setting.

The G.G.C. may also give assistance to a gun that is shooting badly by ordering corrections himself.

3. At the same time it must be clearly realized that during action any corrections for elevation should rarely be applied. With more than one gun firing at a target it is almost impossible for a G.G.C., layer or setter to identify the rounds from any given gun. Night conditions and the excitement attending an action still further enhance this difficulty.

4. The G.G.C. will see that the distribution of fire scheme is correctly carried out by the setters, and ensure that as soon as a boat is disabled fire is turned on to another target.

50. *Advanced look-outs and alarm circuits.*

1. An advanced look-out post (or posts) will be established in such a position as to furnish early warning of any vessel passing through the outer observation lights.

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The sites will be selected in peace time after careful experiment.

The F.C. post, if suitable, may be used for this purpose.

2. Warning will be given by means of an alarm circuit consisting of a generator at the advanced look-out post in direct connection with loud sounding gongs on the gun floors of A.T.C. groups.

3. In some cases a separate telephone circuit is installed in place of an alarm circuit, with the object of avoiding the sending of unnecessary alarms. In such cases the alarm to the guns is sent verbally by the B.C. or other officer when he considers such a message necessary.

4. The F.C. will issue standing orders for the advanced look-out posts.

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CHAPTER VI.

GUN DRILL.

(*See also* the drill of each gun.)

51. *General instructions.*

1. The instructor should place himself where he can be seen and heard by all in the squad; he should stand in a smart, soldierlike attitude; he should avoid pacing up and down, pointing at the gun, handling the equipment except for the purpose of showing how an operation is to be performed, looking down on the ground or up in the air, turning his back on the squad, and similar habits, which have the effect of fidgeting the men and distracting their attention.

2. His explanation should be given with life, vigour, and smartness, in a distinct voice, the tone of which should never be monotonous. He will take great pains to train officers and N.C.Os. under him to practise a good word of command. It should be quick and clear, but not louder than necessary. A drawling word of command makes a drawling, sleepy squad. The instructor himself should always set the best example in this respect.

Stress is laid on these, apparently trivial points, because men unconsciously imitate their instructors. A first-rate instructor will make a good detachment; his manner and style are therefore of the first importance.

It is unnecessary and undesirable to impart the drill to recruits in the exact order in which it is written.

The practice of addressing them with long paragraphs of detail quoted verbatim from the drill is forbidden.

3. The instructor should describe to each man his duties

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at the gun in his own words, which should be so chosen that they will not unduly tax the intelligence of the individual recruit; and he should practically illustrate any point which requires it, by performing the work himself, afterwards requiring the recruit to do it in the same manner.

4. In the first lessons of the recruit in standing gun drill the greater part of the instruction should be given in this manner, description being reduced to a minimum; later on, as the men become more familiar with their work, it will only be necessary for the instructor to remind them verbally of what they have to do and the order in which they have to do it.

5. The drill should be varied every half an hour or so by short descriptions of some portion of the equipment, avoiding manufacturing details, and giving only such as are of use to the practical gunner, such as preparing fuzes, explaining the use of projectiles, and so on.

6. The utmost alertness of attitude and smartness of movement should be enforced throughout gun drill, as these indicate attention discipline and good drill.

7. A detachment should on no account be permitted to pretend to lay a gun; a suitable target should be pointed out to the gun layers, and, when possible, it should be a vessel under way.

8. When a tug is towing a target for instruction in laying or range-finding, it should let out tow line, and layers and observers should be particularly warned to lay on the target and not on the tug.

9. With 4·7-inch and 6-inch Q.F., and 6-inch B.L. Mark VII, where the supply of ammunition is the most difficult and laborious part of the service of the guns, a supply of projectiles should be brought up, and one passed to the loading numbers each time the gun is to be loaded.

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10. A portion of the projectiles should be fuzed with drill fuzes so that the men may attain dexterity in uncapping them previous to loading.

It is advisable that a portion of the drill should be such as will give instruction in firing at long ranges.

11. Instructors drilling infantry at gun drill should avoid the long drill details, to which these men are not accustomed. It is better to show them a trained squad, or a few numbers at drill, and then make them do the same. It is not necessary to teach every man all the duties. The men should only change rounds often enough to learn the duties of two or three numbers. The time allowed an infantry soldier for this drill will seldom permit more to be done.

52. *Falling in and telling off.**

1. A gun detachment consists of a G.C., G.L. or G.Ls., setter or setters, and as many other gun numbers as are necessary, these being laid down for each nature of gun.

The detachment falls in two deep, the G.C. being on the left of the front rank, and the G.L. or G.Ls. on his right, covered by their own setters.

2. On all occasions before giving a word of command, the G.G.C. should repeat the letter of his group, and the gun captain the letter of his group and number of his gun.

3. The G.G.C., having seen that his gun detachments have fallen in correctly, and that the dial numbers, speaking-tube man, telephonists, or orderlies fall in in rear of the group, will then order "A Group, Number detachments from the front."

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* In the words of command given throughout this chapter, the G.G.C. is supposed to be in command of A Group, and the G.C. in command of, and the G.L. at A/1 gun.

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On his command the G.C. of the leading detachment will number "A 1," the remaining G.Cs. numbering off in a similar manner in succession through the groups.

As soon as the detachments are numbered off the G.G.C. will order "A Group, Tell off."

At "Tell off" the G.C. takes a pace to his front, turns to his right, and gives the word, "A 1, Tell off."

The G.Ls. and setters do not number.

The right hand man of the rear rank numbers 2, the right hand man of the front rank 3, the second man from the right of the rear rank 4, his front rank man 5, and so on.

After the detachment is told off the G.C. falls in again on the left of the front rank.

4. The detachment is then moved into the work, and halted in line facing the front, and to the rear of the mounting on the emplacement floor. This is the position of "Detachment rear."

If more than one gun of a group is being manned, each G.C. marches his detachment to his gun as above, or to such other convenient position under cover as the gun group commander may direct.

53. *Preparing for action.*

1. On the command "Prepare for action" rifles are placed in the arm racks, accoutrements and jackets are removed, all gun floor numbers remove their boots and place them under cover, and put on gun floor shoes. The detachment then falls in as before. The gun is then prepared for action in the manner laid down in the handbook of the gun, and in accordance with the instructions for manning a battery or group (Sec. 35). Knee-caps are worn by gun floor numbers.

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2. With all guns, the G.C. will see that the bore of his gun is clear, before even drill shell and cartridge are used; this precaution is particularly necessary at night and before firing blank.

3. When a tube is fired in preparing for action with axially vented guns, the G.C. will see that no one is in front of the muzzle, and in all cases he will be responsible that no charge is in the gun. With disappearing mountings when tubes with balls are used and the tube is fired gun down, he will see that a filled sand bag is placed in front of the muzzle.

4. Lenses of sighting telescopes should be covered over in wet weather, and should be carefully wiped before use.

54. "*Under cover*" and "*Action.*"

1. On the command "A Group (or A 1) under cover," each man doubles at once to his position as detailed in the drill for the gun, the gun being first made safe.

2. In the absence of permanent seats, temporary seats of skidding or other material are to be improvised whenever possible, either at drills or practice, to permit the detachment to sit when under cover.

3. When detachments at gun drill are seated, the position of men at "Attention" will be: the body upright, the knees and heels slightly separated, arms by the side, with the hands resting on the edge of the seat.

4. At "Sit at ease," the knees are allowed to separate further to an easy position, the hands are brought together, right over left, and allowed to hang down between the knees, forearms resting on the thighs, body not rigid.

5. On the command "A Group (or A 1), Action," the whole of the numbers take up the position detailed in the drill, and continue the service of the gun. If the gun has been made

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safe, it will again be made ready, except at Battery Fire (*see* Sec. **65**). To avoid unnecessary exposure, detachments, except those numbers required to keep the gun laid on the target, will kneel or lie down at their positions in action.

55. *"Stand fast" and "Prove."*

1. At the word "Stand fast," the detachment will remain steady in the position they are then in until "Go on," or some other order, is given.

2. To ascertain that the men are in their correct places, the instructor may prove the detachment as follows :—

At "Prove your numbers, G.C.," "2," "3," &c., the number called on will raise his right arm and extend it smartly to the front, hand open and as high as the shoulder, thumb upwards ; when the next number is called, he will drop his arm ; at "Down" the number last called will drop his arm.

56. *To form detachment rear.*

1. Gun Group Commander.	Gun Captain.
"A Group Detachment Rear."	"A 1 Double March."

The G.C. doubles out and places himself in rear of the gun on the emplacement floor, facing to the front ; on the word, "Double march," the numbers double to their places in "Detachment rear," halting and fronting as they come up.

57. *Duties of the gun captain.*

1. The G.C. commands, and is responsible to the G.G.C. for the regular and efficient service of his gun in all respects.

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At practice he is responsible that his gun is laid on the proper target.

When time fuzes are used he is responsible for the setting of them.

2. The G.C. must be prepared to perform the duties of a G.G.C. when necessary.

58. *Duties of the gun layers.*

The G.L.'s duty is laying the gun and firing, except when the arrangement of the mounting makes it inconvenient for him to do so.

He will set his tide lever as ordered by the G.G.C.

When there are two layers, one of them will be responsible for elevation and the other for line.

The layer for line will fire as a rule, or call "Fire" in the case of percussion firing.

See also Sec. 49.

59. *Duties of the setters.*

1. The duties of the setter for range are as follows:—

With auto-sights he will set the deflection scale and error-of-day drum as may be directed His action should be such as to render it unnecessary for the gun layer to remove his eye from the telescope after the target has been picked up, until firing at it ceases temporarily or finally.

2. When a range finder is used he will keep the movable face of the range dial set at the correction ordered including group or gun difference.

3. At Case I he will keep the rocking bar sight set at the deflection ordered and at the elevation shown on the dial (corrected if necessary for group or gun difference).

4. At Cases II and III he will call out the elevation on the dial to the layer at the elevation indicator.

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5. By day the setter for line will set the deflection scale of the pointer to the deflection ordered by the B.C., and subsequent alterations to deflection ordered by the B.C. will be applied to this scale. At the same time he will keep the movable face of the training dial set to the convergence and drift necessary for the range and training.

6. While the gun is being laid for line by the sights, he will prepare for change to Case III by further correcting by the movable face, if necessary, so as to make the dial read the same as the training arc when the gun is fired.

7. At Case III he will call trainings to the layer for line.

8. He will alter the correction face of the training dial in such a manner as to take up differences in convergence when they occur.

9. At night, setters will apply deflection by "blind setting" on the principle that half a turn of the deflection wheel gives 10 minutes' deflection. To ensure giving a good half-turn, setters should count as in the following examples:—

Layer, "40 more right."
Setter, "One, two, three, four."
Layer, "10 more left."
Setter, "One."

See also Sec. **49.**

60. *Loading.*

1. The order to load the first round will be given by the G.G.C., who will name the projectile and charge required. The order will be repeated by the G.C. to his gun.

Except with H.A.F. guns, loading will be continued with the same projectile and charge, without any further word of command, until a change is ordered.

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The G.C. will see that his gun is in a convenient position for loading. When using paper shot with B.L. guns, if the charge consists of more than one portion, the gun should not be loaded or fired at an angle of depression.

2. Projectiles must be rammed well home or erratic shooting may result. Rammer staves are marked so that it can be seen whether the projectile is home or not. Rammers and sponges must be so placed that they will not pick up dirt and grit. Care must be taken in loading to avoid injuring the coned seating for the pad at the rear of the chamber with the point of the shell, especially with 6-inch B.L. Mark VII guns.

3. In loading powder charges, the cartridge cylinder should be kept closed until the rammer has been withdrawn ; then no time is to be lost in introducing the cartridge ; the lids of the cartridge cylinders should be loosened before being taken up to the gun.

4. When firing cordite charges from B.L. and Q.F. guns an escape of flame to the rear on opening the breech is sometimes observed. Gun numbers should therefore not stand immediately in rear when the breech is opened, and bare charges must be kept clear of the breech until the shell has been rammed home.

5. All cartridges for Q.F. guns should be carefully examined for splits and cracks before loading. The provisions of the "Regulations for Army Ordnance Service" regarding the use of cracked cartridge cases will be strictly adhered to.

6. With B.L. guns, under no circumstance will a tube be inserted before the breech is properly closed, except when using electric tubes with 6-inch B.L. VII—X, and 9·2-inch B.L. X.

When using percussion tubes with 6-inch B.L. Mark VII,

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and 9·2-inch B.L. Mark X the lock will be cocked with the breech in the open position and the extractor pressed well home. The breech will then be closed until the lock commences to move, when the tube will be inserted and the breech finally closed.

The breech will never be opened while there is an unfired tube in the vent.

7. If any difficulty is found in inserting or extracting V.S. tubes, they should be slightly greased with Russian tallow. Tubes which have been greased, but not used, should be thoroughly cleaned of the grease before replacing them in their boxes.

8. When carrying out practice from B.L. guns, should circumstances not permit of a gun loaded with a filled and fuzed shell being fired at the end of a day's practice, the cartridge will be withdrawn, and the shell left in the gun until a favourable opportunity offers of firing the round. On no account should an attempt be made to drive the shell out of the gun, which should be chalk marked to show that it is loaded.

61. *Laying.*

1. There are four methods of laying, viz. :—

(*a*) *By auto-sights.*—This, though a special form of the next method, is considered separately. Automatic sights are so devised as to do away with the need of a range finder.

(*b*) *Case I.*—In which sights are used for both elevation and direction.

(*c*) *Case II.*—When direction is given by sights and elevation by elevation indicators.

(*d*) *Case III.*—When direction is given by means of traversing arcs and elevation by elevation indicators.

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2. A "laying teacher" has been issued as an instructional store, primarily to train layers with automatic sights, but also to train them with rocking bar sights and to exercise all ranks in ranging and passing ranges and corrections. Instructions for its use have been issued with this apparatus.

62. *Rules for laying.*

1. To obtain uniform results, the following instructions should be carefully followed :—

In coast defence the point of the target to be laid on is the bow water-line except when otherwise ordered. In the case of a vessel moving directly away from the battery, the guns will be laid on the water-line at the centre of the stern.

2. *Case I.*—Scales must be adjusted at the deflection ordered by the G.G.C. and the elevation called out by the dial number or shown on the range indicator.

The telescope must be properly focussed.

The layer should put himself in an easy position, his feet being placed so that his body is well balanced.

With open sights he will bring his eye on a level with the top of the hind sight and about one foot from it, being careful to keep his eye the same distance from the sight from round to round.

To avoid wearying the eye he should get the sights approximately on the target before carefully looking over them, and then lay quickly.

When the gun is correctly laid, the centre of the line joining the two highest points of the notch in the hind sight, the apex of the foresight, and the point aimed at are in line.

With telescopes the layer will apply his eye close to the eye-piece and bring the tip of the pointer on the point aimed at.

The layer should lay over the target and then depress on to it, thereby avoiding error due to play in the elevating

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gear, except with guns on H.P. mountings, with which the last motion of the elevating gear is always to be one of elevation.

3. *Case II.*—The layer for line will set the deflection leaf to the deflection ordered, and with telescopic sight he will bring the pointer on to the bow water-line.

The layer for elevation will keep his gun laid in accordance with the range called out by the dial number or read out by the setter for range, so that the proper elevation, allowing for the rate of change of range, is continually applied to the gun. He will take care that the last motion of the elevating gear is as laid down for the mounting.

4. *Case III.*—The gun layer will keep the gun traversed in accordance with the training called out by the dial number or setter for training.

The layer for elevation will keep the gun laid as in Case II.

63. *Running up and laying B.L. guns on H.P. mountings.*

1. The normal method of laying these guns will be by Case II, the layer in the manhole using shield sights, and firing by electricity.

2. An alternative will be to lay by Case II from the rear sighting step, using the gun sights and firing by electricity or by percussion.

Exceptionally, Case I may be employed, laying with carriage sights or from the rear sighting step.

3. In all cases the guns will be run up on the word of command, "Stand clear, run up," from their G.Cs. This word will be given on receipt of a signal or order from the G.G.C., except at Gun fire, but detachments will take post to lay as soon as the loading is completed, unless specially ordered under cover. To derive the fullest advantage from

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these mountings, the guns must not be run up a moment sooner than is absolutely necessary, and before being run up must be traversed in the right direction.

4. The G.G.C. will give his order or signal to run up according to the method of fire, as follows :—

At Battery fire, to the gun from which fire is opened, when the order "Commence firing" is received. To the remainder, in time to fire at the proper interval.

At Battery fire, by order, as soon as the order or signal from the B.C. is received.

At Gun fire, G.Cs. will give the order to run up as soon as guns are loaded, provided "Commence firing" has been ordered by the B.C.

The G.L's post in action will be the manhole. He will set his sight to the deflection ordered and keep the gun traversed on the target.

The number laying for elevation will keep his pointer laid on the elevation indicator at about 100 yards less than the range called out.

5. On the word of command, "Run up," or signal from the G.G.C., the G.C. will order "Stand clear," "Run up," and as the guns run up the number laying for elevation will put on the elevation last called out, being careful to check it after the lever has been raised.

6. The number detailed in the handbook will press down the lever of the raising valve as far as it will go and take his hand away, allowing the gun to run up until the pointer on the elevator coincides with the arrow head on the cross head of the ram. When the gun is fully up, he will allow a pause of two seconds and will then close the raising valve completely by raising the lever as far as it will go.

7. To lay from the rear sighting step by Case II the layer will traverse ahead of the target, using shield sights, and

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when the order to run up is given he will mount on the shield, adjust the tangent sight, and hook the lanyard, if necessary, as soon as the gun has risen above the level of the shield, and then proceed to lay from the rear sighting step.

8. To lay by Case I the procedure will be similar to that described in the last paragraph, but the layer will stand on the spring sighting step to complete his laying for elevation, moving to the rear sighting step on the G.G.C.'s order to fire, and completing his laying for line from that position.

9. The drill for Case III is similar to that for other mountings; the elevating number will put on and check the elevation, as described above.

64. *Laying by night.*

1. So long as the target is lit up by the electric light a gun may be laid on it with telescopic sights in the same way as by day, but when laying with ordinary sights, not electrically illuminated, it will be necessary to illuminate the fore sight, which should be chalked, the lantern being held by one of the detachment.

2. There is, however, some difficulty in keeping lanterns alight; the shock of heavy guns often extinguishes them.

65. *Making ready and firing.*

1. There are two distinct methods of firing B.L. and Q.F. guns:—

i. By electricity.
ii. By percussion.

2. Electric firing is the normal method of firing.

3. Percussion firing should only be used when electrical arrangements have failed.

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4. All B.L. and Q.F. guns at all cases of laying will be fired on the following principles. Any special instructions necessitated by variations in equipment will be found detailed in the Handbooks of the guns concerned.

5. *Electric firing*—

(a) *At battery fire.*

After the order to fire has been given by the G.G.C. and "Ready" has been given, the layer who is laying for elevation will complete the laying and call "On." The gun will then be fired by the layer who is laying for line.

With guns having a safety firing plug or automatic circuit breaker, the G.C. will not insert the plug or close the circuit and call "Ready" until the order to fire is given by the G.G.C.

With 6-inch and 4·7-inch guns 2 will not complete the closing of the breech and call "Ready" until the order to fire is given by the G.G.C.

(b) *At gun fire.*

As above (except that no order to fire is necessary) provided "Commence firing" has been ordered by the B.C.

The G.C. will insert the plug or close the circuit as soon as his gun is ready and run up and detachment clear.

6. *Percussion firing.*—As above, except that the layer for line calls "Fire," when the gun is fired by the number detailed in the handbook of the gun.

With old pattern guns at battery fire the layer will not cock the lock until the order to fire is given by the G.G.C.

7. R.M.L. guns used as anti-torpedo craft guns are fired by electric tubes from an observing station above the emplacement. The G.C. will insert the safety firing plug as soon as his gun is run up and ready and detachment clear.

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66. *Procedure on missfire occurring.*

1. *Radially vented guns.*—The G.L. will remove the missfired tube, prick the cartridge and insert a new tube, taking care to keep himself clear of the recoil. In the event of the second tube missing fire, after a pause of one minute it will be removed, some powder poured down the vent and a new tube inserted and fired.

A powder horn with F.G. powder is provided for this purpose.

2. *R.B.L. guns with vent pieces.*—When a missfire occurs, one or more fresh tubes may be tried; if they missfire also, after a delay of three minutes, the breech will be opened and the primer examined.

3. *Axially vented guns.*—In case of a missfire two things require to be done:—

i. Examine the tube to see whether it has fired or not.
ii. If the tube has fired, open the breech, after a definite period laid down for each nature of gun, and adjust or exchange the cartridge after a further pause.

The procedure in (i) varies with the nature of lock employed; in (ii) with the nature of the gun.

For details of procedure, *see* drills of various guns.

4. *Q.F. guns.*—In the case of a missfire the breech is opened after a pause of five minutes and the cartridge is extracted after a further pause of one minute. For further details, *see* drills of various guns.

5. 1-*inch A.R.*—The breech is opened and cartridge removed after a pause of one minute.

6. For disposal of cartridges, *see* Regulations for Magazines.

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67. *Making guns safe.*

1. The order "Make safe" will be given when a gun has been loaded and it is not intended to open fire immediately. This order will always be given before detachments of loaded guns are ordered under cover. For precautions when "Stand fast" is sounded at peace practice, *see* "Instructions for Practice Seawards." The procedure on the command "Make safe" will be found in the drills for various guns.

2. On the order "Action" or "Commence firing" guns will be again made ready to fire, except at battery fire, as detailed in Sec. 65.

With Q.F. guns at percussion firing the breech will be closed gently.

68. *Instructions as to firing salutes and blank.*

1. In firing salutes there will be an interval of not less than 15 seconds between rounds.

2. With B.L. guns, not less than six guns will be used for salutes, and with Q.F. guns not less than four. No B.L. gun will be reloaded with a bare charge within 30 seconds after firing, and no Q.F. gun within 15 seconds.

3. With all M.L. ordnance no gun will be reloaded within one minute from the time of firing; if there are less than seven guns in the saluting battery the interval between rounds will be proportionately lengthened to allow of this.

4. Vent servers should invariably be supplied, and the officer firing the salute will see that they fit correctly. He will also examine the sponges to see that they are not low to gauge.

5. The party detailed to fire salutes will consist of three numbers per gun, with a minimum proportion of one non-commissioned officer to every two guns; the whole under the

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command of an officer assisted by a serjeant, or the master gunner in charge of the work.

No officer, non-commissioned officer or gunner is to command or form part of a section or gun detachment firing blank ammunition at salutes, who has not been trained and passed in gun drill.

6. *Drill*—The G.C. commands and fires.

2 sponges and rams home. With B.L. and Q.F. guns, opens the breech.
3 loads.

7. Side-arms and water buckets will be provided for each gun, and 2 should see that the sponge is kept damp. It should be *sprinkled* with water, and not saturated by being dipped in the bucket.

8. When firing 12-pr. Q.F. with blank charge the felt jacket will on no account be removed from the filled cartridge bag.

9. All the guns will first be loaded by order of the officer in charge; after firing, each gun will be sponged out and reloaded by order of the master gunner or serjeant, who will be responsible that the minimum interval prescribed has elapsed since the gun was last fired.

10. **With 6-inch B.L. Mark VII gun, after each round, the chamber will be sponged out with a damp sponge, the piasaba brush passed completely through the bore, and the mushroom head wiped with the sponge or a damp cloth.**

11. The guns will be fired in succession from a flank by order of the officer in charge, who is responsible for the interval between rounds, as required under the instructions given above.

12. The officer in charge before giving the order to fire,

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and the master gunner or serjeant before giving the order to load, will place themselves immediately in rear of the gun to which the order is given.

13. The tube will not be placed in the vent of a M.L. or R.B.L. gun until the order is given by the officer in charge "No..... gun, ready"; this order will be given immediately after the previous gun has fired, with 5-inch B.L. guns the lock will not be cocked until "Ready" is given.

14. In the event of a missfire, the next gun in succession will be ordered at once to fire, and the gun at which the missfire occurred will not be fired again until its turn comes round.

15. In firing blank with B.L. and Q.F. guns, in the event of a missfire, the breech of the gun will not be opened for at least one minute when firing powder, and ten minutes when firing cordite. When it is opened at the expiration of these periods, great care must be taken that none of the detachment are directly in rear of it. An officer or senior non-commissioned officer should be detailed for the special duty of timing the interval after a missfire, and informing the G.C. of that gun when he may open the breech.

16. For procedure on missfire with M.L. and R.B.L. guns, *See* Sec. **66.**

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CHAPTER VII.

GUNS AND GUNNERY.

(*See also* the "Text-Book of Gunnery" and the Handbook of each gun.)

69. *The gun.*

A gun is designed to discharge a projectile of a certain weight with a certain maximum charge; the muzzle velocity, and consequently the range for any particular elevation, will vary with the charge used. With guns that use only one charge the curve of the trajectory is fixed for any given range, and is, generally speaking, kept as flat as circumstances allow. With howitzers and high-angle fire guns with which more than one charge is used the curve of the trajectory can be varied at short and medium ranges by selecting a suitable charge. The longest ranges can only be attained by using the full charge.

70. *Velocities and pressures.*

1. The high velocities required of modern guns can be obtained only by high total pressures, the result of using large charges.

2. If a quick burning propellant were used, great initial pressures would result, and the gun would have to be very thick in metal at the breech to withstand them.

High initial pressures also cause much wear and erosion in the bore, and would consequently shorten the life of the gun.

3. The pressures inside a gun, due to the explosion of the charge, must therefore be distributed, as much as possible throughout the whole length of the bore.

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This is effected by using a slow burning propellant, the rate of ignition of which has been adjusted to give a steady uniform pressure as the projectile moves up the bore of the gun.

4. Theoretically, to get the full benefit of a slow burning charge, a very long gun is necessary, so that the cartridge may be entirely consumed just as the projectile leaves the bore, and the maximum amount of work obtained from it. Practically, the length of a gun is limited by such considerations as weight, handiness, and strength of material.

71. *Air spacing.*

1. In modern guns, the capacity of the chamber is greater than is required to contain the cartridge, so as to allow of "air spacing." It was discovered that the greater the space the charge had to burn in, the less would be the maximum pressure in the gun, and the less also would be the velocity imparted to the projectile. The pressure was found to fall off much more quickly than the velocity. Thus, by regulating the air spacing, large charges can be used, and high velocities obtained, with only moderate pressures.

2. With modern guns the necessary air spacing is obtained by increasing the diameter, rather than the length, of the chamber. A long chamber tends to set up "Wave pressures," which are detrimental to the safety of the gun.

72. *Gun construction.*

1. Modern guns consist of an "A tube" over which layers of wire or flat steel tape are wound under a tension graduated for each layer, the exterior of the wire being protected by a jacket. All heavy and most medium guns are now constructed with an "inner A tube" in order to

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facilitate the repair of eroded guns. In the larger guns the jacket is supplemented by a "B tube." The wire gives great circumferential strength, combined with accuracy of tension, and certainty as to the soundness of the material. Longitudinal strength, which is absent in the wire itself, is obtained by the support given to the A tube by the jacket, or by jacket and B tube combined. Guns built on this system are lighter than guns of equal power built on the all steel system.

73. *Object of rifling.*

The objects of rifling are to obtain accuracy and to enable an elongated projectile to be used.

The rifling imparts sufficient spin to the projectile to ensure its travelling point first throughout the range.

Accuracy is attained by ensuring that the projectile is truly centred as it leaves the gun.

74. *System of rifling.*

1. Modern guns are rifled by cutting numerous shallow spiral grooves down the bore, leaving ribs of metal, called "lands," between the grooves. The projectile has a band of tough metal, called a driving band, secured to it near the base. On discharge, during the passage of the projectile down the bore of the gun, the lands cut into the driving band, and force the projectile to follow their spiral course and to rotate.

2. The system of rifling may be considered under two headings :—

i. The shape of the grooves.
ii. The twist at which they are cut.

i. In the modern polygroove system the grooves are shallow, so as to weaken as little as possible the

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metal of the gun, and are numerous, in order to distribute the stress over the whole circumference of the bore. The various natures of polygroove rifling differ from one another chiefly in the number of grooves per calibre, and the radius at which their loading and driving edges are cut. In the most recent design the grooves have driving edges normal to the circumference of the bore, and the lands are reduced to a minimum, in order to reduce, as much as possible, the amount of metal cut away from the driving band, and thus to prevent "stripping."

ii. Twist may be either uniform throughout the whole length of the bore, as in old type guns and in those of most recent manufacture, such as the 60-pr. B.L., or increasing in pitch from the breech to the muzzle, as with all modern guns except the latest.

The twist of the grooves, at any point of the bore, is measured by the rectilinear distance a projectile would travel, to turn once about its longer axis, provided the twist remained uniform from the point considered. This distance is measured in calibres of the gun. Thus, a twist of 1 in 40 means that the projectile would make one complete revolution in 40 calibres.

3. When increasing twists superseded uniform twists, the following advantages were claimed for them :—

i. More certain grip of the projectile during its first movement, when the pressure in the bore is the greatest. Less wearing away of the bore, owing to the better sealing effect of the band. With the introduction of cordite, which, in its early form, had an extremely erosive effect, the rifling grooves were

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even left straight for some distance at the breech end. This was done so that the gas should have the minimum erosive effect on the bore during the time its temperature and pressure were highest.

ii. Less initial strain on the gun and projectile, and a more even rotation pressure throughout the bore, since the spin is imparted gradually to the projectile.

3. The disadvantage of increasing twist is that it alters the form of the driving band, since the lands have continually to cut fresh grooves as the pitch of the rifling alters.

With long guns and high velocities there is an increased tendency of driving bands to wear, and this avoidable source of extra friction is undesirable.

4. For these and other reasons the uniform twist has been reintroduced in the latest guns where high velocities are required. The introduction of cordite M.D. has in great measure rendered this possible. The temperature of combustion of cordite M.D. is much less, and so also is the erosive effect, compared with cordite Mark I. The advantage of the improved sealing effect given by a straight piece of rifling is outweighed both by the lower mean pressures and higher ballistic effects obtained with uniform rifling.

75. *Breech mechanisms.*

1. With B.L. guns the interrupted screw system is employed. Two patterns are in use in the service.

2. In the first, the breech screw is cylindrical, the surface is divided into a number of equal parts, and the threads are removed from alternate parts, both on the breech screw and in the gun.

Therefore the breech screw can be pushed into the gun by a direct motion, and locked by being turned through part of

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a circle. The breech is actuated by a cam lever requiring four motions to unlock the breech screw and unseat the obturator, and in the heavy guns some form of gearing is necessary to withdraw it, since the breech screw has to be long to give the necessary number of threads for strength, and is therefore heavy.

3. In the second pattern (known as the Welin screw) the breech screw and breech of the gun are stepped, as shown in Fig. 4. (The figure shows the breech screw (without the obturator) turned into the closed position.)

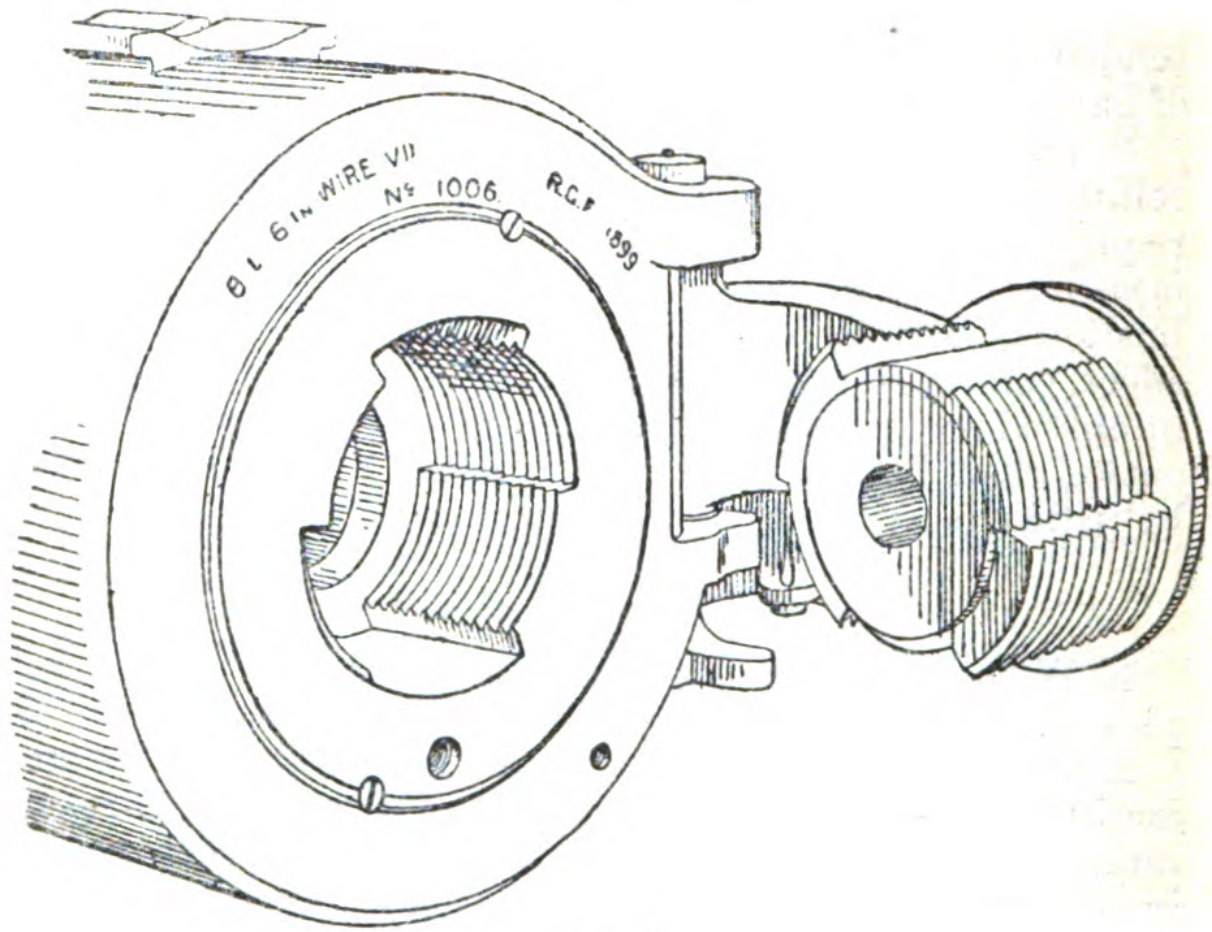

Fig. 4.

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In large screws, nine segments are screwed and three left plain.

By this system a larger proportion of the block is threaded than in the cylindrical system; the block can therefore be made shorter for the same strength. This allows of its being inserted and turned by one continuous motion of a lever in conjunction with a carrier hinged to the breech of the gun.

4. Certain old 6-inch guns have been converted to use a single-motion system known as B.L.C., and the 60-pr. B.L. gun has a peculiar cylindrical breech screw and single-motion mechanism of its own.

5. With Q.F. guns two systems are employed.

6. In the first, used with 12-pr., 4-inch, 4·7-inch, and 6-inch guns, there is a cylindrical breech screw with a truncated cone at the front end. Both the cylindrical portion and the coned portion are provided with interrupted screws, the plain portion on the cylinder being behind the threaded portion on the cone.

Pressure is thereby distributed through the metal of the breech screw, while the form of the block admits of its being inserted and locked by one motion of a lever.

7. In the second system, used with 3-pr. and 6-pr. guns of old pattern (employed chiefly as sub-calibre guns), the breech of the gun is slotted across, and some form of wedge is lowered in the slot by a lever at the side of the breech, so as to give access to the chamber of the gun for loading.

8. The wedge system, in conjunction with semi-automatic devices for opening and closing the breech, is employed in some of the latest pattern Q.F. guns. In these guns the wedge can be actuated by a lever, but, when set for semi-automatic working, the discharge of the gun causes the breech to open and the cartridge case to be ejected, while the act of insertion of the next round causes the wedge to rise.

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76. *Breech obturation.*

1. Breech obturation, or the prevention of escape of gas past the breech screw, can be divided into two main systems :—The "de Bange" system, and the Q.F. system.

2. The "de Bange" system is used with all B.L. guns, and consists of a mushroom-headed spindle passing through the breech screw, with an asbestos pad between the mushroom head and the face of the breech screw. The mushroom head is driven back by the explosion of the charge, and squeezes the asbestos pad against the face of the breech screw, causing it to expand outwards and press against the bore. The escape of gas past the breech screw is thus sealed.

3. In the Q.F. system, the charge is contained in a metal cartridge case, which is expanded to fit the chamber by the pressure of the powder gases when the gun is fired. In the larger natures of modern guns, and in high velocity light guns such as the 4-inch Mark VII, the weight of the case and the necessity for air spacing, which entails enlarged chambers, preclude its use.

77. *Means of firing.*

1. A B.L. gun is fired by means of a tube placed in the vent, and actuated by a lock. Q.F. guns, 12-pr. to 6-inch, are fired by a primer, or an adapter containing a tube, screwed into the base of the metal cartridge case, and actuated by a striker ; 3-pr. and 6-pr. Q.F. guns are fired by a percussion cap or percussion primer fixed in the base of the metal cartridge case.

2. Tubes and primers are brass cylinders closed at the head. The means of firing is contained in the head, the body being filled with powder to pass on the flash to the

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cartridge. Tubes and primers materially differ from one another only in the shape of the brass cylinder.

3. There are three natures of tubes, electric, percussion and friction; and two of primers, electric and percussion.

4. Electric tubes and primers are fired by means of a current of electricity, which heats a bridge of platinum alloy. This fires a priming of guncotton and composition, which in turn ignites the powder in the body.

5. Percussion tubes contain a percussion cap in the head, and are fired by the striker hitting the head of the tube.

6. Percussion primers, used with 3-pr. and 6-pr. Q.F. guns, contain a cap and are fired by the striker hitting the cap.

7. Electric tubes and primers are very safe to use, but uncertain and liable to missfire. This is due to various causes, such as the platinum bridge breaking, or the electric current being short-circuited, or the leads broken.

8. Percussion tubes are very certain, but not so safe as the electric. They must be used with care, as they are liable to explode if knocked or jarred.

78. *Method of attachment to the mounting.*

1. Until comparatively recently guns were attached to their mountings by means of trunnions. These fitted into trunnion holes in the carriage and enabled the gun to be elevated or depressed; both gun and carriage recoiled together.

2. All modern guns are trunnionless. They fit inside a cradle and recoil through it. A recoil checking device keeps the gun in the cradle, and feathers on the gun fitting into

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featherways in the cradle, or some similar arrangement, prevent the gun turning in the cradle.

The cradle does not recoil with the gun.

The sights are carried on the cradle instead of on the gun, and this enables continuous laying to be carried out. (Sec. **97.**)

79. *Forces acting on the projectile in the bore.*

1. The following are the chief forces to be considered :—

   i. The force of propulsion, or the pressure on the base of the projectile, by the gases liberated when the cartridge is fired. This force drives the shell forward.

   ii. The force of rotation, or the pressure of the driving edges of the rifling on the driving band. This causes the shell to rotate.

2. The following are some of the conditions which affect the pressure on the base of the projectile :—

   i. The amount of gas developed, depending on the weight and nature of charge.

   ii. The speed with which the gas is developed, depending on the shape and size of the cordite sticks.

   iii. The heat to which the gases are raised. The greater the heat developed when the charge is fired, the more the gases will be expanded, and the greater the pressure. Cordite M.D. develops less heat than Cordite Mark I, and consequently a greater weight of charge is required to give the same pressure.

   iv. The temperature of the charge before firing. In the case of cordite, the hotter the charge is the more

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violent will be the explosion. Range tables for cordite are made out for a certain temperature of charge. Should the temperature of the charge differ from the range table temperature, different results may be expected in the shooting. In all modern range tables will be found the information as to the alteration in M.V. caused by an alteration of 10° F. in the temperature of the charge. Cordite alters its temperature slowly, and the temperature of the charge may be taken as that of the magazine where cartridges have been taken direct from the magazine to the gun floor.

v. Air spacing. The greater the amount of air spacing the less the initial pressure.

Air spacing is calculated for in a gun with the projectile properly rammed home. Want of uniformity in ramming will affect the air spacing and so the initial pressure. Worn B.L. and Q.F. guns allow the projectile to be rammed home too far, thus causing an increase of air spacing, and a decrease of initial pressure. Projectiles not rammed home sufficiently may cause high pressures in the chamber of the gun or loss of pressure as described in sub-para. vi.

vi. Complete obturation, and the sealing of the escape of gas between the projectile and the bore of the gun by the driving band. If gas escapes, loss of pressure and damage to the gun by wearing and scoring will result.

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80. *Muzzle velocity.*

1. Muzzle velocity is the speed with which the projectile leaves the bore. It depends on the sum of the pressures acting on the base of the projectile all the way up the bore, and, consequently, on the length of the gun as well as on the charge.

2. Friction between the driving band and the rifling has a retarding effect on the shell, as also has the weight of the shell itself, in consequence of its inertia having to be overcome. For any given gun and charge, the lighter the projectile, the higher the muzzle velocity.

3. Energy is spoken of as "muzzle energy" when measured at the muzzle, or "striking energy" when measured at the target.

81. *Forces acting on the projectile during flight.*

1. The projectile leaves the gun with a certain velocity and rotation, and if it were acted on by the force of projection alone, it would go on for ever in a straight line, and pass over equal spaces in equal times.

2. Two forces, however, act on the projectile during flight: the resistance of the air, and the attraction of gravity, or the attraction of the earth.

82. *Resistance of the air.*

1. The air consists of innumerable small particles pressing against each other and everything touching them. The projectile on leaving the bore at once meets, and has to thrust aside, these air particles, and thus gradually loses its velocity.

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For instance, the muzzle velocity of a projectile from a 6-inch B.L. Mark VII gun, full charge, is 2,493 feet per second. After the shell has travelled 1,000 yards its velocity has fallen to 2,202 feet per second, and at 10,000 yards to only 927 feet per second.

2. The amount of the retardation of a projectile in the air depends on its weight, length, diameter, shape of head, and steadiness in flight, and on the density of the air.

3. With projectiles of the same weight and length, that with the smallest diameter will offer less resistance to the air, and will range further. The heavier shell of two of the same diameter and muzzle velocity will maintain its velocity better. The weight obtained by using a very long shell is theoretically of great value; but, practically, various considerations limit the length. Very long shells are unsteady in flight, and so lose velocity and accuracy.

Certain shapes of head will push aside the air more readily than other shapes.

4. The resistance of the air differs from day to day. Heavy air has greater resistance than light air, and cold air than hot air. The amount of moisture in the air alters its resistance, but only very slightly. The presence of moisture reduces the resistance offered.

83. *The acceleration due to gravity.*

1. The acceleration due to gravity causes a body to fall with a constantly accelerating velocity, *i.e.*, the rate at which the body falls gets quicker and quicker the further it falls.

2. This acceleration, acting on the projectile immediately it leaves the muzzle, draws it down from the line of departure

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faster and faster the longer it is in the air. The projectile is thus caused to move in a curve instead of a straight line.

In Fig. 5 suppose AB to be the line of departure, and that the shell has a velocity which would take it to C at the end of the first second, and to E, G and B at the end of the second, third and fourth seconds respectively. (Note each successive distance is smaller owing to the resistance of the air.)

The acceleration due to gravity will draw it down a

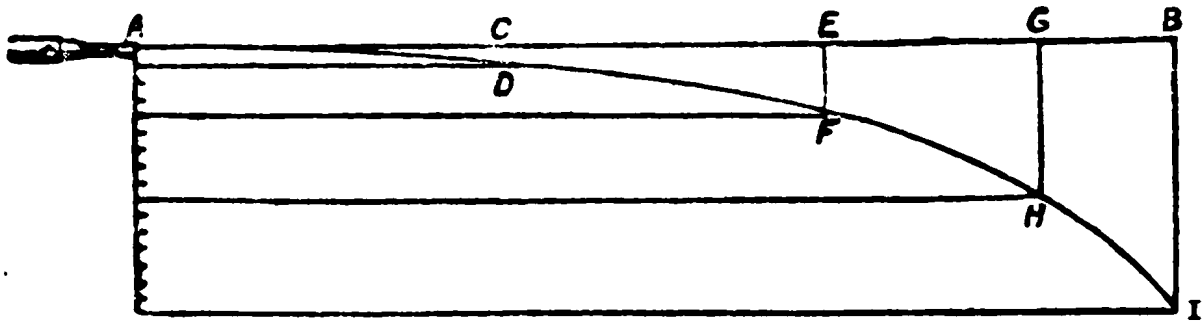

Fig. 5.

distance CD in one second, EF, or four times as far, in two seconds; GH, or nine times as far, in 3 seconds; BI, or 16 times as far, in 4 seconds, and so on, the distance in a vacuum being expressed by the formula $\frac{1}{2}gt^2$, where $g = 32{\cdot}19$ feet and $t =$ the time in seconds.

The path of the shell will therefore follow the line ADFHI, the curve of which is due to the action of gravity. The shape of the curve is affected by the resistance of the air.

3. The air opposes resistance to the downward, as well as to the forward movement, but the amount is but small with

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a heavy body like a shell. For instance a 10-inch shell drops in

1 sec.	...	...	15·3 feet
2 „	...	...	60·5 „
3 „	...	...	137·3 „

Without the support of the air it would drop in

1 sec.	...	...	16·1 feet
2 „	...	...	64·4 „
3 „	...	...	144·9 „

these being the amounts found, by the above formula, for a body falling in a vacuum.

84. *Drift.*

1. The air acts on a rotating projectile after it has left the bore, so that it deviates continually to one side from its original direction. This deviation is called drift. The amount of drift is measured by actual experiment. It differs for each particular nature of gun and charge. The service rifling has a right-handed twist; this imparts a right-handed spin to the projectile and causes the projectile to drift to the right.

85. *Wind.*

1. Wind blowing with or against the projectile has the effect of increasing or shortening the range for any particular elevation, and wind across the range causes the projectile to deviate from the plane of departure.

2. The effect of the wind as affecting range and direction depends on the speed of the wind and on the angle with the line of fire at which it acts and also on the time during which it acts, *i.e.*, on the time of flight.

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86. *Trajectory.*

1. The curve a projectile describes through the air, due to the action of all the above enumerated forces, is called its trajectory.

2. With flat trajectories and with moderate angles of sight the trajectory is assumed to be quite rigid, *i.e.*, the projectile is considered as describing the same shaped curve, for a given tangent elevation, whether the line of sight be horizontal, or pointing up or down.

87. *Sights.*

1. Since the force of gravity causes a projectile to fall from its line of departure, it is necessary, in order to hit a given target, to direct the axis of the gun to some point above it. This is termed giving elevation to a gun.

2. It is obvious that a low velocity gun must be given more elevation than a high velocity gun to hit the same target. The projectile from the former will take longer to arrive at the target, will consequently be acted on for a longer time by the force of gravity, and will therefore fall further in the same longitudinal distance.

The axis of a gun may be given the proper amount of elevation above the target by means of sights.

88. *Tangent elevation.*

1. With modern guns, the means of giving tangent elevation is the rocking bar sight. This consists of a bar of steel, pivoted to the cradle, and carrying a sight bar, on which are the fore and hind sights and telescope.

2. If inclination be given to the rocking bar with reference to the axis of the piece and the line of sight then made to cut the target, the gun will have been elevated

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through a certain angle. If the gun has been elevated the correct amount and the line of sight correctly laid on the target, then the trajectory should pass through the target.

3. Within certain limits the more a gun is elevated, the further a shell will travel, and, with a given gun, a given angle of elevation will correspond with a given range.

Thus instead of graduating the tangent sight of a gun in degrees and minutes of elevation it can be graduated in yards of range corresponding to the angles of elevation necessary for those ranges.

The graduations of a tangent sight at short ranges will be closer together than those at long ranges, since the trajectory becomes more curved the longer the range.

89. *Quadrant elevation.*

1. Once the tangent elevation has been determined for a particular range, the quadrant elevation for that range is found by adding or subtracting the angle of sight according to the relative heights of objective and gun.

2. In coast defence guns firing from a known height over the sea, the angle of sight is always the same (not considering the rise and fall of the tide) for a particular range. Thus quadrant elevations and their corresponding ranges can be tabulated for each gun.

3. Quadrant elevation can be applied to a gun, either by means of a clinometer placed on the gun, or by an elevation indicator by which the yards corresponding to angles of quadrant elevation can be read.

90. *Auto-sights.*

1. Given a certain height above the sea, every range has its corresponding angle of sight or depression. This is the principle of vertical base range finding.

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Also, at this height, with a given gun, every range has a corresponding quadrant elevation.

2. The principle of the auto-sight is to maintain such a relation between the depression angle and the quadrant elevation of a gun (whose height above M.S.L. is known) that, when the sight is laid on the water-line of any object, the gun shall have the correct quadrant elevation to hit that object.

For effective limit of auto-sights, *see* Appendix II, Sec. 18.

91. *Sighting telescopes.*

1. Sighting telescopes are fixed in "Y" brackets so that the axis of the telescope is parallel to the sight bar.

2. The telescope contains a pointer at the focal distance of the object-glass. Thus, if the telescope is in adjustment and the eyepiece is properly focussed, all that is necessary to lay the gun is to align the pointer on the target by means of the elevating gear of the gun.

The advantages of the sighting telescope over open sights are :—

i. Easier and more regular laying, since only two points—the tip of the pointer and the target—have to be aligned instead of three—the notch of the hind sight, the tip of the fore sight, and the target.

ii. The target is magnified by the telescope and finer laying can be carried out.

92. *Deflection and drift.*

1. All sights have deflection leaves so that the axis of the gun may be laid to the right or left of the target to compensate for wind, travel of target, &c.

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2. Drift is compensated for by inclining the carrier of a rocking bar or automatic sight at a suitable angle, so that when the sight is set for any range the hind sight moves a suitable amount to the left, corresponding approximately to the amount of deflection required to correct the deviation of the projectile and bring it on the target.

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CHAPTER VIII.

GUN MOUNTINGS.

93. *Requisites of a gun mounting.*

1. The following are the requisites of a gun mounting :—

i. It should afford a compact and stable platform for the gun.

ii. It should admit of easy service of the gun, including elevating and traversing, the gear for which should be independent of recoil and admit of all round traverse.

iii. It should limit the recoil of the gun and provide for its automatic return to the firing position without jarring the mounting.

iv. It should admit of continuous laying by two layers, one of whom elevates while the other traverses, while at the same time one of the layers can fire the gun.

v. Verticality of pivot should be ensured and a ready means provided of restoring verticality if lost.

94. *Stable platforms.*

A stable platform is essential to accuracy. In a fixed mounting this is obtained by means of a massive pedestal bolted to an anchorage embedded in a concrete emplacement.

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95. *Easy elevation and traverse.*

Ease and rapidity in elevating and traversing are obtained by the use of ball bearings, or live roller rings, which reduce friction to a minimum, by good balance and by suitable gearing as free from backlash as possible, and actuated by handwheels placed in convenient positions for the layers.

96. *Absorption of recoil and automatic running-up.*

1. For absorbing recoil some form of hydraulic buffer is used in all modern mountings. The gun slides axially through a portion of the mounting termed the cradle; a buffer cylinder is attached to the gun and a piston and rod to the cradle or *vice versâ*. On recoil, the piston is made to pass from end to end of the cylinder, which is filled with liquid; the liquid has thus to pass from one side of the piston to the other through a port or opening cut in the piston for the purpose.

2. The velocity of recoil is greatest at the commencement and would set up severe strains. To avoid this, and to equalise the pressure inside the cylinder and the pull on the piston rod during recoil, a valve key, in the shape of an inclined plane, is bolted longitudinally inside the buffer. The port cut in the piston fits over this key, which is so placed that the flow space through the port is greatest just after the commencement of recoil, and is gradually constricted as the port comes over the higher portion of the valve key.

3. A portion of the energy of recoil is utilized to run the gun up again into the firing position. The gun is kept in the firing position by means of springs or air under initial compression. The action of the gun in recoiling adds to this compression, and when the energy of recoil is entirely

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absorbed, the compressed springs or air recover, and in doing this automatically return the gun to the firing position.

4. To prevent the gun running out with violence, and causing damage to the mounting, a control ram is fitted inside the recoil cylinder, either to the piston or the end of the cylinder. When the gun is in the firing position the control ram fits into a cavity ; during recoil the control ram is drawn partly out of its cavity and the space vacated fills with oil. As the gun runs forward this oil is expelled by the control ram. The fluid resistance thus offered checks the forward movement of the gun and brings it gently to rest in the firing position.

97. *Continuous laying.*

1. To provide for continuous laying, the sights and elevating and traversing gears are attached to non-recoiling portions of the mounting and the handwheels actuating the gears are arranged so as to be under the control of the layers. The sights thus form part of the mounting and not of the gun. (Sec **78.**)

2. The attachment of the sights to non-recoiling portions of the mounting enables the principles of the automatic sight to be successfully applied to modern mountings.

98. *Quadrant elevation—means of applying.*

1. With modern mountings the amount of quadrant elevation given to a gun is ascertained from the elevation indicator. This generally consists of a circular plate, graduated in yards of range, carried on one end of a horizontal shaft. Fitted to the other end of the shaft is a pinion, actuated by a toothed arc attached to the cradle. Thus any motion of elevation or depression given to the gun

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causes the graduated plate to revolve past a stationary reader and allows the graduation on the plate, corresponding to the quadrant elevation of the gun, to be read off.

2. The elevation indicator is carried on the mounting under cover, and is placed adjacent to the lower elevating handwheel.

3. When giving quadrant elevation by elevation indicators, or when laying with auto-sight, it is essential that the mounting should be absolutely level, *i.e.*, that the pivot should be truly vertical.

4. The elevation indicator is only a means of determining the elevation of the gun in relation to the mounting; if therefore the mounting be out of level the wrong quadrant elevation will be given to the gun. Both the level of mounting and the accuracy of the reading of the elevation indicator should always be tested before firing. The method of doing this is described in Chapter XII.

5. When using auto-sights the slightest inaccuracy of level in the mounting introduces a source of error.

The modern mounting is provided with means of either adjusting or compensating for want of level.

6. Mountings of light and medium guns can be levelled by driving in steel wedges under the pedestal. Certain mountings are provided with correctional gear to compensate the auto-sight for any slight uniform tilt of pivot.

99. *Traversing arcs.*

1. A gun can be laid under cover for direction by means of a traversing arc. This is an arc of metal, graduated in degrees and half and quarter degrees, either let into the floor of the emplacement or attached to the pedestal of the mounting. A pointer attached to the mounting reads on

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the traversing arc and indicates the training of the gun with reference to true North.

2. For the sake of uniformity all later arcs are oriented, so that when the pointer is at zero on the arc the axis of the gun will be bearing true North, and the degrees are so numbered that when the pointer indicates 270 degrees, the gun will be laid due East, and when 90 degrees due West.

Older arcs differently oriented may still be met with.

3. If more than one gun be laid by traversing arc with the same training, their lines of fire will be parallel. A correction, known as convergence, must be applied to the training of guns other than the pivot gun in order to concentrate their lines of fire on the target. (*See* App. II, Sec. 7.)

Traversing arcs do not make allowance for drift. (*See* App. II, Sec. 6.)

100. *Attachment of dials to the mounting.*

1. The necessity for rapid and accurate passing of ranges and trainings has led to the attachment of electric range and training dials to the mounting.

2. The range dial is placed close to the drum of the rocking-bar sight or to the elevation indicator, and the training dial close to the pointer of the traversing arc. Thus the readings of the dials can be quickly and accurately transferred to the gun.

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To face page 131.

Plate 1.

SHOT &c. WITH NO BURSTING CHARGE.

A. P. SHOT STEEL

PALL SHOT IRON

PRACTICE COM. SHELL

SPECIAL CASE SHOT

WHITE DISC

PLAN

SHELL WITH RED BAND TO DENOTE "FILLED."

A. P. SHELL STEEL

COM. SHELL STEEL

H. E. COM. SHELL STEEL

4184. 16397/45. 5000. 8. 15.

Malby & Sons, Lith.

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CHAPTER IX.

AMMUNITION.

(*See also* "Treatise on Ammunition.")

101. *Projectiles.*

1. The projectiles provided in the equipment of 9·2 and 6-inch guns of the fixed armament are A.P. shell and H.E. shell for the attack of ships. In a few special cases shrapnel shell will be found for guns firing over land fronts.

4·7-inch, 4-inch, and 12-pr. Q.F. guns are equipped with H.E. shell.

Case shot are used with R.M.L. guns intended for A.T.C. defence.

2. The following projectiles will also be met with :—

Shell.

Common (to be used up for practice).
Common pointed.

Shot.

Armour piercing and Palliser (to be used up for practice).
Solid. For practice.

The distinguishing marks shown on Plate I should be known by all ranks.

3. A.P. shell are forged or cast and the points are hardened, the burster is of L.G. powder in "lasting cloth" bag. The earlier A.P. shell were filled with P mixture in a dowlas bag.

The incendiary effect with powder bursting charges is valuable.

The latest pattern of A.P. shell for 9·2-inch B.L. guns (except H.A. fire guns) is a capped shell. The cap enables.

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a greater thickness of armour to be perforated, and improvements in ballistics also result from the shape of the cap.

4. Certain projectiles are fitted with night tracers.

A night tracer consists of a device for fitting to the base of a projectile, which, on the discharge of the projectile from the gun, burns with a bright light, enabling the flight of the projectile to be traced.

Tracers are external to the projectile with fixed ammunition and internal with separate ammunition.

Tracer-fitted projectiles are on no account to be fired unless either the tracer or plug is in place and tightly screwed up. With separate ammunition the plug should always be used when firing these projectiles by day.

5. Lyddite shell are made of forged steel, with solid bases to prevent any chance of premature action from the penetration of gas through a base fuze or between the plug and body of the shell.

Lyddite shell for guns of the fixed armament are now filled solid : with 6-inch and 9·2-inch guns 7 dram exploders of picric powder are placed under the fuze.

Lyddite is four times as powerful as gunpowder if it detonates, and a little stronger than powder when it explodes.

If a lyddite shell detonates completely, the smoke of the burst is all black ; if it only explodes, the smoke is yellow.

A shell filled with lyddite has an all round effect on explosion, whereas with a powder charge the fragments travel forward.

Lyddite shells have little incendiary effect.

Lyddite shell cannot be detonated by being struck by another shell, except by another lyddite shell which detonates ; 3 inches between shells is sufficient to prevent detonation.

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An A.P. shell striking a lyddite shell will explode it, but neighbouring shell will not be exploded.

6. Shrapnel shell are found in the equipment of 9·2-inch and 6-inch B.L. guns, when they are to be used for firing over land fronts. They are made of cast steel. Those for 9·2-inch guns contain 2 ozs. sand shot and those for 6-inch guns mixed metal balls, 14 to the pound, they have a bursting charge in the base, and a primer in the head to convey the flash from the fuze to the powder.

7. Case shot consists of an envelope made of tinned sheet iron, with a disc of sheet iron at each end, strong enough not to set up on discharge, but weak enough to break up at the muzzle of the gun and release the steel balls with which it is filled.

102. *Driving bands.*

1. Driving bands are made of copper.

2. The first driving band was the narrow Vavasseur. The broad Vavasseur was then introduced; this has cannelures to take up the copper that is drawn to the rear during the passage of the shell up the bore.

3. The gas-check type is a later form of driving band, introduced for use with cordite charges. This is a very much broader band, with a second slope formed near the centre of the band, and the metal grooved inrear of it, thus forming a lip or gas check.

The lip prevents over-ramming of the projectile in worn guns. The groove in rear of the lip is made so as to be exactly filled by the lip when pressed down; this prevents fringing.

Projectiles fitted with gas-check driving bands are fitted with rope grummets to protect them in store and transit.

4. The latest type of driving band, made from solid

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drawn copper, for 9·2-inch and 7·5-inch projectiles, is shown in Fig. 6, and a somewhat similar band, but with a serrated front slope, is used for all natures below 6-inch calibre.

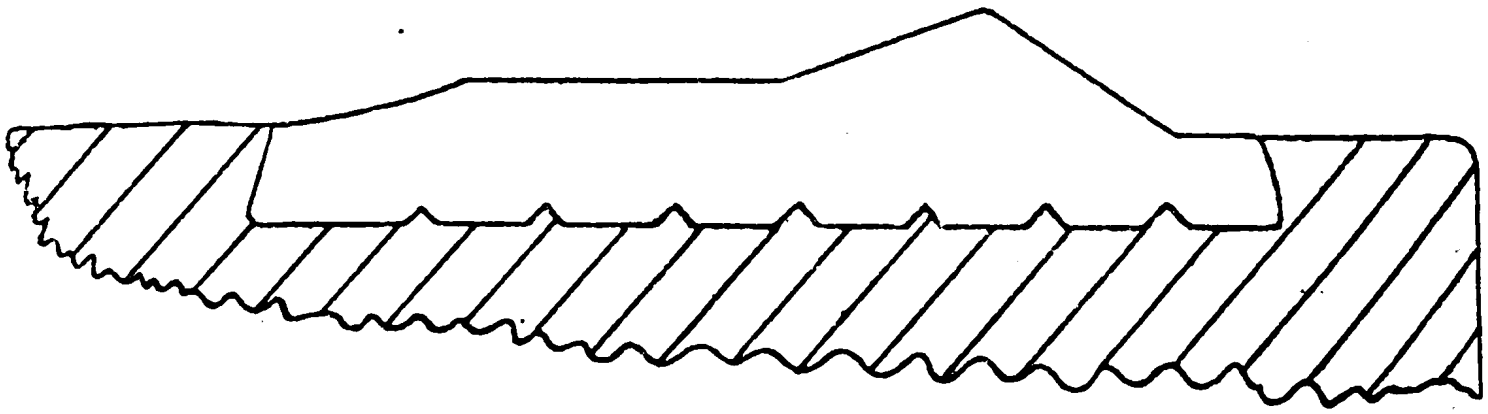

Fig. 6.

5. Augmenting strips are for use with projectiles having broad Vavasseur driving bands, in cases when the rifling of a gun has become much worn. They should be fitted in the rear cannelure of the driving band, and gauged so that the extreme diameter is approximately the same as that of the gas-check driving band of the later marks of projectiles.

They are not intended to give rotation but to prevent overramming, to seal windage, and to hold the projectile till the pressure of gas is developed.

6. Augmenting rings are fitted to 9·2-inch 380-lb. projectiles. They are made of copper, and fit into and fill up the groove in rear of the gas check portion of the driving band.

The use of augmenting rings is confined to gas-check bands.

7. A pattern of driving band differing from that used when the range tables were compiled may have a considerable effect upon the range attained.

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103. *Fuzes.*

1. Fuze D.A. Impact No. 13 is used for coast defence with H.E. shell 6-inch and upwards, and D.A. Impact No. 18 with 4·7-inch Q.F. and smaller natures.

2. To prepare these fuzes remove safety pin and cap.

3. Fuze, percussion, base, large, No. 11, is used with common pointed and A.P. shell without caps. Fuze, percussion, base, large, No. 16, is for use with capped A.P. shell. No preparation is necessary.

4. The Mark I patterns of fuzes No. 11 are less sensitive than Mark II and later Marks, and so are not suitable for reduced charges.

5. Fuzes T. and P., No. 64, are used with the shrapnel shell of 6-inch B.L. guns. To set the fuze the cap is loosened and the time ring moved round until the required graduation is opposite the pointer. The cap is then screwed down as tightly as possible.

Both pins will be removed at the moment of loading, unless the shell is required to burst on impact, in which case the P. pin only will be removed.

104. *Cordite.*

1. There are two sorts of cordite in the service, known as cordite Mark I, and modified cordite (cordite M.D.) respectively.

2. Cordite consists of nitro-glycerine, guncotton, and mineral jelly, incorporated together and gelatinized with the aid of the solvent acetone. The greater part of the acetone is driven off by drying, which is the final process of manufacture.

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The proportions of the ingredients are :—

	Mark I.	M.D.
Nitro-glycerine	58	30
Guncotton	37	65
Mineral jelly	5	5

3. Cordite is generally in the form of sticks or cords, which are formed by pressing the incorporated materials through a die.

M.D. cordite has been made in the form of tubes, when it is known as M.D.T. The object of the tubes is to obtain a more constant burning surface and therefore more constant evolution of gas.

4. After drying, batches of cordite are mixed into blends and blends are mixed into lots. A lot may consist of any quantity of cordite up to 30,000 lbs. according to the size of the cordite.

5. Cordite is distinguished by a number representing in hundredths of an inch the diameter of the hole in the die through which it was pressed, and the length of the sticks is shown. With cordite M.D.T. the external and internal diameters of the tube are given. Examples--

Cordite M.D., size 37, length 33 inches.
Cordite M.D.T., size 20—10, length 7 inches.

6. *Properties of cordite.*—Cordite in good condition is smooth and tough and has little smell.

Cordite M.D. is horny, harder, and more brittle than cordite Mark I.

Cordite is poisonous.

It can be fired by percussion, but if ignited in the open, burns away without explosion.

It can be detonated, and its action is then nearly as powerful as that of guncotton.

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It suffers from exposure to direct sunlight, but not when enclosed in cartridges.

It is not affected by damp or water. A wet charge can be fired if the igniter will fire. Before returning a wetted charge to store it should be dried. Cordite is almost smokeless, the products of combustion being nearly all gases and containing no solids which would cause smoke.

To guard against danger arising from decomposition, cordite cartridges are periodically tested.

7. *Cordite in the gun.*—Cordite is slow burning compared with gunpowder, and on this account the maximum pressures are low and the pressure on the projectile in the bore is well sustained. Cordite M.D. is still slower burning,

Charges are difficult to ignite, particularly those of cordite M.D., an "igniter" of guncotton yarn or F.G. powder is therefore used to extend the flash of the tube.

The rate of burning of a charge is affected by the size of the cordite; a charge of large-sized cordite burns more slowly than one of small.

The effect on the muzzle velocity of the temperature of the charge before firing varies with every nature of gun.

Great erosion of the bore is caused by the very high temperature evolved by cordite Mark I. To minimise this, cordite M.D., having a smaller proportion of nitro-glycerine, was introduced.

Cordite causes a tendency for bores to rust.

It gives a very bright flash at the muzzle of the gun.

With heavy guns care should be taken not to expose a bare cartridge to the back flash that sometimes occurs when firing to windward.

105. *B.L. cartridges.*

1. Silk cloth and shalloon are used for making up cartridges.

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2. An igniter is invariably necessary for cordite cartridges, and consists of R.F.G. powder, and, in some cases, guncotton yarn, in shalloon. Some igniters have been made of sulphurless gunpowder, as it was thought that the presence of sulphur caused deterioration of the cordite. The use of sulphurless powder is not continued in the latest igniters.

3. The heavier cordite cartridges are divided into fractions for convenience in handling, &c. The fractions for 6-inch Mark VII and 9·2-inch B.L. guns in the Land Service are as follows :—

6-inch ...	...	$\frac{1}{2}$ charge.
9·2-inch ...	...	$\frac{1}{2}$ and $\frac{1}{4}$ charges.

4. With the 6-inch Mark VII the two portions are laced together, and each portion has the igniter at one end only. This consists of R.F.G. powder between discs of shalloon, cross stitched to form four compartments, so as to ensure some powder being opposite the tube when the cartridge is placed in the gun. A strengthening disc of shalloon is sewn to the underside of the igniter, to prevent the sharp edges of the cordite spikes injuring the shalloon. The cartridge has four felt studs at the igniter ends, to prevent the latter from touching the mushroom head.

5. Cartridges for 9·2-inch B.L. Mark X are either composite or cordite M.D.

Each portion has an igniter at one end, consisting of R.F.G. powder, similarly arranged to that of the 6-inch cartridge, but cross stitched to form eight compartments in recent manufacture.

A millboard protecting disc is lightly attached over the igniter. This must be torn off both portions of the charge before loading.

Cartridges for 6-inch and above are issued in zinc cylinders.

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106. *Q.F. cartridges.*

1. Q.F. ammunition differs from B.L. in having its charge in a brass case.

3-pr. and 6-pr. ammunition is "fixed," having the projectiles attached to the case.

The charge for 3-pr. and 6-pr. guns is of cordite. The arrangement of the charge varies in the different patterns. Cartridges fired by a percussion cap have an igniter. In those fired by a percussion primer there is no igniter. Cartridges are issued in boxes holding 11 rounds in the case of 6-pr. boxes, 16 rounds in the 3-pr. boxes.

2. The 12-pr., 4-inch, 4·7-inch, and 6-inch Q.F. have the projectile and cartridge case separate.

The charge consists of long sticks of cordite, nearly the full length of the case. Various arrangements are made in the different marks of cartridge to enlarge the hinder end of the charge, so that it forms a firm base and centres the charge in the bottom of the case. The igniter consists of a cylinder of cordite, 1 inch in diameter, to the top of which is sewn a shalloon bag containing F.G. powder. Some igniters are of sulphurless gunpowder.

The cylinder of cordite is principally for keeping the space free for the primer or adapter.

The cartridges are issued in boxes which hold ten 12-pr. cartridges, eight 4-inch, six 4·7-inch, or four 6-inch Q.F.

107. *Primers.*

1. The Primer, electric, large, is used with Q.F. guns, and screws into the hole in the base of the brass cartridge case. The latest mark is the Mark V. The Mark IV** and any other Marks *** have been brought up to date and been given a strengthened bridge similar to the Mark V.

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2. Adapters are the same shape as the primer, and bored out to take a V.S. tube, either electric or percussion.

3. Primers, percussion, are used with some of the cartridges of 3-pr. and 6-pr. Q.F. guns.

108. *Tubes.*

1. For igniting charges in B.L. guns, tubes, electric or percussion, are employed. They fit a seating in the vent accurately, and are held in the vent by the lock.

2. The heads of the tubes are closed to prevent the passage of gas through them, while the tube itself is expanded against the walls of the seating, and so prevents the escape of gas past it.

3. The 9·2-inch Mark X and the 6-inch Mark VII use the tube V.S. electric, wireless, P., and the tube V.S., percussion. These tubes are also both employed with Q.F. guns in cartridges fitted with adapters to take the place of the electric primers.

The percussion tube is blackened outside and has four notches cut in the rim of the head so that it may be distinguished from the electric wireless by sight or touch.

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CHAPTER X.

ELECTRICITY.

109. *General remarks.*

1. The following notes will help to explain a simple electrical circuit, such as the firing circuit of a gun. For further information *see* "Notes on Electricity" and "Regulations for Magazines and Care of War Matériel." Officers will also make themselves acquainted with "Military Electric Lighting, Vol. II," and with "Instructions for Provision and Maintenance of Electrical Communications in Fortresses."

2. The power termed electricity, used in the artillery service for firing guns, producing incandescent light, ringing bells, actuating dials and working telephones, may be produced either by a chemical process in an electric battery, or by putting in motion a machine called a dynamo. Simple forms of dynamo are met with in the "Field service exploder" and in the "Magneto Bell."

110. *Circuit.*

1. To obtain a so-called "current" of electricity, a complete "circuit" must be provided through the battery or dynamo, leaving it by one terminal or "pole" passing through a "conductor," usually copper wire, to the tube or instrument actuated, and returning to the other pole.

2. As the current travels by the easiest path permitted, it must be confined to the conducting wire by "insulators" such as gutta-percha, ebonite or silk.

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Any bridging of the external circuit, diverting the current from its proper path, is known as a "short circuit."

3. In many circuits, the current, being led by an insulated wire to the point where its work is to be performed, is allowed to return through a mass of metal, and this is generally known as an "earth return."

When a circuit is broken by an air space, the current ceases to flow; this enables breaks, which can be closed by plugs, keys, &c., to be made.

111. *Cells.*

1. The most valuable generator of electricity for artillery purposes is the "Leclanché cell," two patterns of which are largely employed, namely, the "A Mark III" for firing batteries, and the "C Mark I" for position finders, &c.

2. A Leclanché cell consists of a plate or rod of zinc and a plate or rod of carbon, both immersed in a solution of sal ammoniac. When the carbon and zinc are connected by a conductor outside the cell the sal ammoniac consumes the zinc, and in consequence an electric current flows.

3. "Dry cells" and "inert cells" are similar in principle to Leclanché cells. The former are issued ready for use, the latter require to be charged with water.

4. The current is said to leave by the positive pole—(that is to say, in the case of the Leclanché cell the head of the carbon)—to pass along the conductor, and to return to the negative or zinc pole. This is the external portion of the circuit; the path along the plates or rods themselves and across the sal ammoniac which completes the circuit is the internal portion.

When the zinc is attacked the carbon becomes covered with bubbles of hydrogen gas, which reduce the power of the cell by "polarising" it.

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These bubbles are removed, as they form, by "depolarisers' consisting of carbon and peroxide of manganese placed round the carbons. The oxygen in the depolariser removes the hydrogen by combining with it and forming water.

5. When cells are unsatisfactory, it will generally be found that the depolariser is worn out, or that the circuit within the cell has become bad owing to high resistance between the carbon and the terminal fixed into it.

6. The greatest care must be taken to prevent the carbon and zinc plates becoming connected, otherwise than by the working circuit.

7. The effect produced on a tube or instrument depends upon the current passing through it. The amount of current depends on the power of the cell or battery of cells and the total resistance in the circuit, and is given by the formula :—

$$I = \frac{E}{R},$$

in which I is the current in ampères,
E is the "electromotive force" of the battery in volts,
R is the total resistance in the circuit, in ohms

Example :—Compare the currents, when testing and firing a tube, with the usual circuit and pistol grip.

The resistance of the bridge of a tube when cold is 1 ω.
" " " " at fusing point is 2·9 ω
" " indicator coils is 80 ω.
" " leads is negligible.

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Suppose the four cells to have each: E.M.F. 1·3 volts, internal resistance ·3 ω.†

Testing—

$$I = \frac{4 \times 1{\cdot}3}{4 \times {\cdot}3 + 80 + 1} = \frac{5{\cdot}2}{82{\cdot}2} = {\cdot}063 \text{ ampères.}$$

Firing—

$$I = \frac{4 \times 1{\cdot}3}{4 \times {\cdot}3 + 2{\cdot}9} = \frac{5{\cdot}2}{4{\cdot}1} = 1{\cdot}2 \text{ ampères.}$$

8. The tube being designed to fire with a current of 0·8 ampères, there is no risk of firing when testing the circuit, and there is ample current when the indicator is cut out.

112. *The instrument testing primary batteries.*

1. The "Instrument, testing primary batteries, Mark II*," is designed to test a battery of cells as well as a single cell, and may also be used to ascertain the voltage and internal resistance of a cell.

2. *To test cells, Leclanché, C, Mark I*—

See Manual of Coast Defence Range Finding.

3. *To test a firing battery*—

i. To test the cells in series, cover the button, set switch to number of cells. If reading is less than 1, examine the cells separately.

ii. To test a single cell rapidly, set switch to 1, take reading pressing the button, and reject the cell if the reading is less than 1.

---

† A new cell, Leclanché A, Mark III, should have E.M.F. 1·5 volts with internal resistance ·15 ω.

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iii. To ascertain the voltage and internal resistance of a cell, set switch to 1, take reading "*a*" without pressing button. Press button and take reading "*b*" (without waiting). Find the information required in the table attached to the instrument, using the values of *a* and *b* just obtained.

4. *Caution.*—The lead from the + pole of the battery should always be taken to the *red* terminal of the instrument.

On replacing the instrument, the reader at the back should be set to read 6 cells.

118. *The volt-ammeter.*

1. The instrument consists of a "moving coil" galvanometer and certain resistances.

On pressing the button marked "Volts" the moving coil is put in circuit with a high resistance between the terminals.

On pressing the ampère button a very low resistance is connected between the terminals and at the same time the moving coil with another resistance in series with it, is connected in parallel with the low resistance.

In the first case the high resistance is so adjusted that 10 volts on the terminals will pass a current which moves the index to 10 on the scale.

In the second case the very low resistance allows the cell under test to send practically its maximum current, and of this current a small portion passes round the moving coil. The extra resistance in series with the latter is so adjusted that if 10 ampères flow through the instrument as a whole, the current through the moving coil shall be just sufficient to move the index to 10 on the scale. In other words the current through the moving coil is the same in both cases.

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2. *To test Leclanché cells—*

i. *Volts.*—Connect any number of cells up to six in series with the instrument, press the button marked "Volts" and observe the reading. Should this not exceed n by 1 volt (n being the number of cells), the cells should be tested separately, and any cell not giving 1 volt should be re-made.

ii. *Ampères.*—Connect each cell successively to the instrument, press the button marked "Ampères" for about 3 seconds and observe the reading. Any cell not giving a reading of 4 ampères should be re-made.

114. *Care of cells.*

1. It is of great importance that cells be kept in a serviceable condition. They should be frequently tested for voltage and internal resistance, and carefully examined to see that they are free from faults.

Connections and binding screws should be clean and dry.

2. The following are some reasons for a cell failing to do its work :—

Fault.	Remedy.
i. The liquid low from evaporation.	Fill up with water or replace with new solution.
ii. Solution exhausted.	Take the cell down, wash and clean parts in warm water, &c.; assemble with fresh solution.
iii. Internal resistance abnormally high as shown by tests.	Examine lead cap and terminal of carbon; if there is a white deposit between cap and carbon, lead chloride (a bad conductor) has been formed.

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Fault.	Remedy.
	This is also proved by tests being better when the contact maker is pressed against the carbon instead of on the terminal.
	Replace carbon or replace complete cell.
iv. Depolariser exhausted.	This is indicated by cell running down rapidly when being tested.
	Replace depolariser.

115. *Firing circuits.*

1. The diagram in Fig. 7 is given as a typical example of a firing circuit. The connector is only shown on one side for the sake of clearness and the plug box is not shown as the leads B, C, and E are permanently joined therein.

116. *Pistol grip, Mark III.*

1. The Mark III pistol grip enables the tube or primer and the circuit generally to be tested at the moment before firing. It can be used on any mounting fitted with a connector pistol grip.

In addition to the trigger there is a lever contact, the function of which is to close the circuit through the indicator by means of the plunger.

When the lever contact is depressed a current passes through the indicator coils.

2. This testing current is not sufficient to fire the tube or primer, but when the trigger is pulled the indicator coil is short-circuited and the tube or primer is fired.

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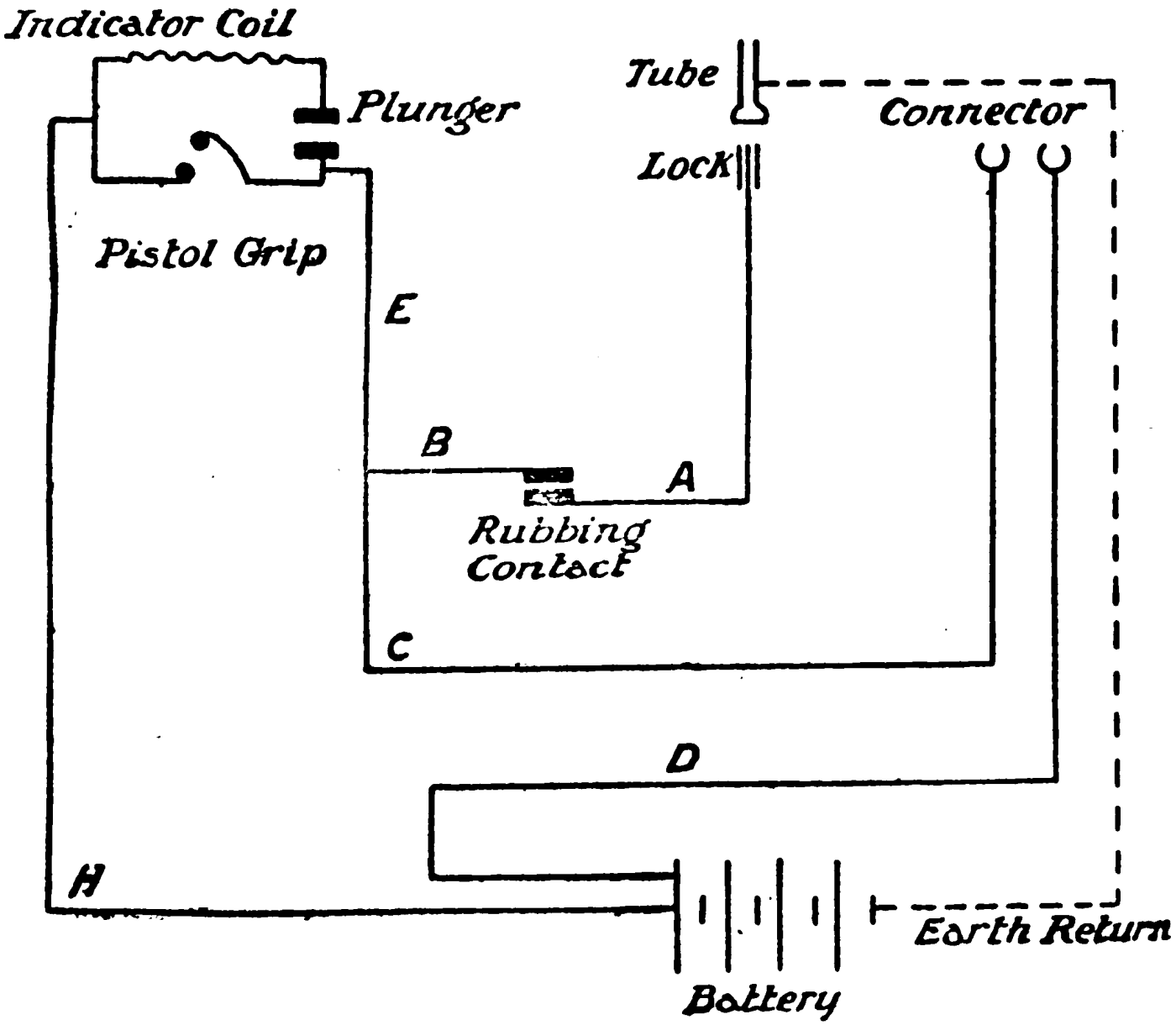

Fig. 7.—6-inch, Mark VII, Firing Circuit.

3. The efficiency of the pistol grip and its connector may be tested, in conjunction with the rest of the firing circuit, as described in Sec. 119.

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117. *Care of circuits.*

1. Missfires may occur from the following causes as well as from weak cells :—

i. Bad contacts and loose binding screws.
ii. Breaks in the circuit.
iii. Oil or dirt between the contacts.
iv. Short circuiting.
v. Defective primers or tubes.

2. To deal with the above :—

i. All contacts should be examined frequently to see that they are tight, that the springs in spring contacts are in good order and that the binding screws do not work loose during firing.
ii. Pistol grips must be treated with care to avoid damage. Spare leads should be available to replace faulty ones.
iii. Oil may cake on contacts and form an insulating surface.
iv. Short circuit may result from crushed or defective insulation, which may be caused by screwing contacts too tight. They may be discovered by testing each lead separately.
v. Defective primers and tubes are not common but a bridge may be broken, or of so low a resistance that the current will not raise the heat to fuzing point. Bridges are often broken by rough usage in handling, and special attention should be paid to this point.

3. The continuity of circuits in primers and tubes should be tested with the pistol grip, under the precautions laid

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down in Sec. **122**, paras. 7 and 8. It must not be overlooked that a short circuit will also work the indicator.

4. It is advisable to test all primers and tubes for resistance as well as for continuity. This is best done by the Wheatstone bridge method described in Sec. **122**.

118. *Overhauling firing circuits.*

1. Remove battery box, cable connection to battery box, leads, connector pistol grip, cradle contact, and gun contact. Disconnect all connections inside the battery box and remove the cells, taking out the two centre cells first. Remove the cork plugs. (This assists the cells to recover.) The battery box should be dried and the copper straps thoroughly cleaned and examined to ascertain that there is no break between them and the connection to the insulated stud at the positive end of the box, and the box itself, at the negative end. They should then be given a slight film of paraffin oil : this prevents the formation of verdigris.

2. Scrape the ends of the corks and cane centres, and see that the inner end of the cane is flush with the bottom of cork. See that the cells are filled to within 1·5 inch of the top. Clean the terminals with bathbrick, and binding screws and connecting wires with emery cloth, and give a slight film of paraffin. Put the short pieces of copper wire on the positive poles only, so that they will be ready to connect up when replaced in the battery box. They must be put under both binding screws so that the top one locks the lower one. Test the cells separately and see that they are not below the minimum readings given in Secs. **112**, **113**. Replace cells in battery box, connect up in series, and replace corks. Take care that the copper straps do not rest on the corks, as the sal-ammoniac solution will soon eat through them. Take the reading at the battery

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box for the 4 cells, from the stud on the rear for the positive end, and the box itself for the negative.

Then test to see that there is no short circuit between the battery box and the insulated stud and its connection at the positive end.

3. Thoroughly clean the cable connection to battery box, connector pistol grip, plug box in 9·2-inch Mark X and 6-inch Mark VII, cradle contact, gun contact, contact electric carrier (and contact electric breech screw in Q.F. guns). See that the insulating bushes are complete. Test each in circuit with an I.T.P:B. or volt ammeter and a cell, both for continuity and also to see if there is a short circuit. Test each lead for continuity and for short circuit. This should be done with the lead straight and also bent, as it is very often the case that although the lead tests correctly when straight, when on the mounting and bent, a make and break in continuity or a short circuit appears.

Whenever H, D, or K leads are disconnected from the connector to pistol grip they should also be disconnected from cable connection to battery box, or they may touch some part of the mounting and short circuit the battery.

4. Now fit each lead to its contact, and see that there is a good metallic contact, and that when screwed home there is no longitudinal play, as, although the pin connection on the end of the lead may be opened out, the jar of the mounting on firing will often close it in, and a break in the circuit is caused by the pin being held central by its securing screw. If there is longitudinal play, pack up the recess in the contact with lead, till end of pin contact is well home on it, taking care that in pushing the lead home in the connector too much force is not used.

5. Overhaul and test striker or lock for protrusion and short circuit.

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6. Replace connections and leads, see that the bracket which carries the gun contact is properly screwed home to the gun, as, if not, a broken plunger will be the result. Secure the pins that secure the boxes of gun and cradle contacts by lashing them with stout twine to the handles of their brackets.

7. Clean the pistol grip and place it in position, clamping it with the jamming block in the connector. If, when screwed hard home, the pistol grip is still loose, lash the pistol grip in position.

119. *Testing circuits.*

1. Open breech, put breech screw in fully locked position by releasing catch retaining breech screw open or, with B.L. guns, remove the lock from the slide box, and pull trigger and test the circuit at the point of striker or lock by means of I.T.P.B. by placing red wire on point of striker or lock and black wire on breech screw.

The reading should not be less than 1·3.

For test with volt-ammeter *see* Sec. **113**, 2 (i).

2. Still keeping the trigger pulled, depress the lever indicator, the indicator should not appear.

3. Release the trigger and depress the lever indicator, the indicator should appear. (If it is required to test the resistance of the indicator, which should be about 80ω, a Wheatstone bridge should be used.)

4. Close the breech, press the lever indicator, and there should be no deflection, if there is there is a short circuit which should be remedied. (A short circuit in H, D, or K leads will not be indicated.)

5. During wet weather firing circuits should be frequently tested in order to detect any short circuit due to the rain.

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120. *Testing tubes and primers.*

1. The following table shows the high and low limits of resistance of the bridges of service tubes and primers, and also their average resistances :—

Tubes, V.S., Electric, Wireless, P.

Marks II and III.—Resistance 1·5 ω to 1·8 ω, average 1·65 ω.
Marks IV and V.—Resistance ·9 ω to 1·1 ω, average 1 ω.

Tubes, V.S., Electric, P.

Mark VII.—Resistance 1·5 ω to 1·8 ω, average 1·65 ω.

Primers, Electric, Large.

A.—"Strengthened." Iridio-platinum bridge. Resistance ·75 ω to ·95 ω, average ·85 ω.
B.—"Converted." Platinum-silver bridge, single. Resistance 1·5 ω to 1·8 ω, average 1·65 ω.
C.—"Unconverted." Platinum-silver bridge, double. Resistance ·6 ω to ·9 ω, average ·75 ω.

A.—Mark I***.	B.—Mark I**.	C.—Mark I.
Mark II***.	Mark II*.	Mark I*.
Mark III***.	Mark II**.	Mark II.
Mark IV**.	Mark III*.	Mark III.
Mark V.	Mark III**.	Mark IV.
	Mark IV*.	

2. A rapid method of ascertaining whether the resistances of bridges of tubes or primers are within the above limits is as under, and is known as the Wheatstone Bridge test :—

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Stores required—

Coils, resistance, 10,000 ohms ...	1	
Galvanometer, 800 ohms ...	1	
Leads, length 1 yard	2	(connecting battery)
Leads, length 2 yards	2	(connecting galvanometer)
Leads, length 3 yards	2	(connecting to gun)
Cells, electric, Leclanché A, Mark III	1	

3. To connect up. (*See* Fig. 8.)

Open the box and see that all plugs are clean and screwed in, and with Mark II box, place two plugs horizontally in commutator on right side.

Connect the + pole of cell to terminal A (zinc) and the – pole to terminal B (copper).

Connect the galvanometer to terminals C (galvo) and D (galvo), place needle on its pivot and balance it at zero.

Connect a lead to terminal F (line) and end of needle, and another lead to terminal E (earth).

4. Test resistance of leads and striker—

Place line E on firing pin point. Unplug resistances in each arm of the bridge (*a* right) (*b* left).

A dividing bridge will be required (*i.e.*, small right, large left), and the following bridge will be found suitable when testing the leads, tubes, and primers.

Unplug 10 in arm *a* and 1,000 in arm *b*.

Then 1,000 : 10 : : *c* : *x*.

Unplug "infinity" in arm *c*, press Key 2 firmly and snap Key 1, and note direction needle is deflected.

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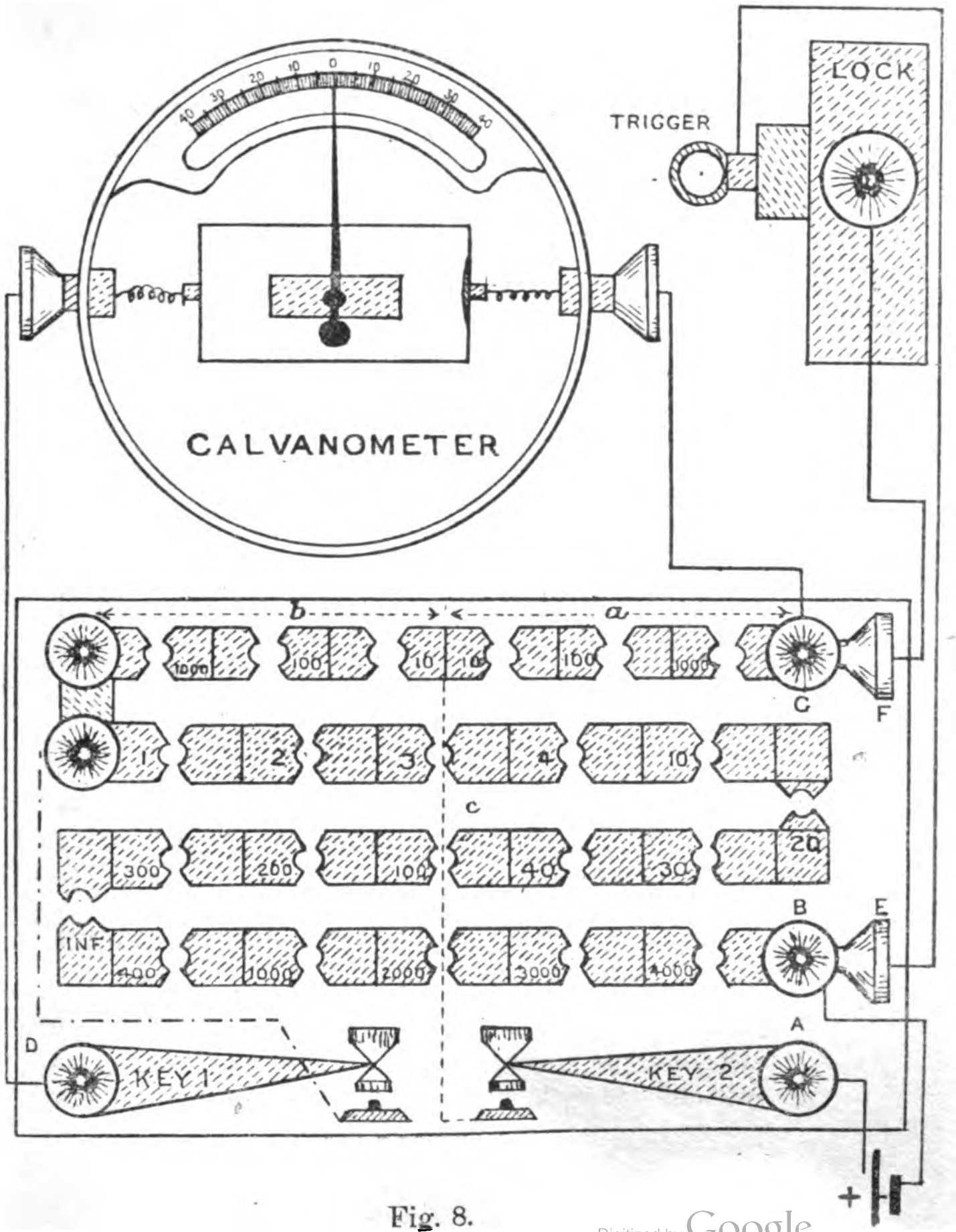

Fig. 8.

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Replace infinity plug and remove a plug or plugs which will cause the needle to be deflected in opposite direction when keys are pressed; then, by manipulating the plugs, a value will be ascertained at which the needle remains steady at zero when the keys are kept pressed.

When this occurs, C and D are points of equal potential.

Note value of resistance unplugged in *c* and apply value of bridge to ascertain the resistance of the leads and striker.

Example.—

$$a = 10, \quad b = 1000, \quad c = 1, \quad d = x.$$

$$\therefore \quad 1000 : 10 :: 1 : x,$$

$$x = \frac{10}{1000} \times 1 = \cdot 01\ \omega.$$

5. *To test tubes or primers*—

Connect line E to trigger of lock or striker.

Place a tube or primer in the gun, and proceed as in 4. In this way you ascertain the combined resistance of leads, striker, and bridge.

Add the resistance of leads and striker to the resistance given in above tables, and reject any tubes or primers which are not within these limits.

6. Having obtained a correct result, use this tube or primer as a standard for testing the remainder, and proceed as follows:

i. Remove plugs equivalent to the maximum resistance of bridge plus resistance of leads and striker, press keys, and note deflection of needle.

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ii. Remove plugs equivalent to the minimum resistance of bridge plus resistance of leads and striker, press keys, and note deflection of needle.

iii. Remove plugs equivalent to average resistance given in table. Tubes or primers which do not cause the needle to swing beyond the limits noted, when the average resistance is unplugged, and the key is pressed, may be considered correct.

7. All tubes and primers must be tested in the gun.

8. With E and F locks the striker should be pulled slightly to the rear while the breech is being closed and opened.

121. *Telephones.*

1. The care of cells, and the continuity of circuits are the most important matters to be attended to in connection with telephones.

2. The following tests, in case of breakdown, are reprinted from "Notes on Electricity":—

Telephone, Portable, "A," Mark I.

Rough tests—

(*a*) *To test call circuit.*—Disconnect line wires, turn handle of generator, bell should not ring.

Short-circuit line terminals, turn handle of generator, bell should ring strongly.

(*b*) *To test speaking circuits.*—Disconnect line wires, close pressel switch in hand telephone, blow into microphone; sounds should not be heard in the receiver.

Short-circuit line terminals, close pressel switch, blow into microphone, and sounds should be heard in the receiver.

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Tests in detail.—If the rough test (*a*) fails: place a battery and detector (high resistance coil) in series with the line terminals; there should be a deflection with the auto switch *down*.

If there is a deflection, then the fault is due to a mechanical defect in the generator, which should be examined.

If the rough test (*b*) fails:

i. Test primary circuit by breaking it at the most convenient point, viz., the two lower (microphone) terminals on front of box, and inserting the low resistance coil of a detector, there should be a deflection *only* when the pressel switch is pressed.

ii. To test secondary circuit, join a two-cell battery and detector (high resistance coil) in series with the line terminals.

With the auto switch *up* a deflection should be obtained.

Telephone, Portable, "C," Mark I.

Rough tests—

(*a*) *To test the bell circuit.*—Turn handle of generator with line wire disconnected, bell should not ring.

Insert plug between the two small brass strips of the lightning discharger (or connect line terminals), and repeat; the bell should now ring loudly.

(*b*) *To test speaking circuits.*—(1) Place receiver of telephone to ear, close pressel switch; on blowing into microphone no sounds should be heard. (2) Insert plug between brass strips, and repeat; sounds should now be heard distinctly in receiver.

Tests in detail.—If the bell fails to ring, it may be due to a mechanical fault at the generator, such as the rubbing

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contact not touching the armature, or the bell armature may be out of adjustment.

To put either of these mechanical faults right, it will be necessary to open the central partition of the instrument by disconnecting the battery wires at Z and K, and then removing the holding down screws.

As the top is a neat fit it will require careful handling. If sounds are heard in the receiver when applying the first portion of test (*b*) the line terminals are in some way short-circuited.

If second portion fails, a fault must exist in either the primary or secondary circuit, or perhaps both.

To test the primary circuit for continuity, connect a current detector (low resistance coil) in series with it at any convenient point, say at battery, close pressel switch, when a deflection should be obtained in the detector.

If not, look carefully to the battery connections by removing the metal covers from the cell boxes, and then test each cell by connecting the detector (low resistance coil) between the positive and negative of each, when a hard over deflection should be obtained; if not, the battery should be replaced by a new one.

If the fault has not been detected, tap the microphone gently, as the carbons may have packed a little. If still undetected, trace out the circuit carefully with a battery and detector in series.

To test secondary circuit, join a two-cell battery and detector (high resistance coil) in series with the line terminals, the plug not being inserted.

When the pressel switch is closed, a deflection should be obtained in the detector. A deflection is also obtained when this switch is released; the current in this case flows round the bell circuit.

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It is the deflection when the switch is pressed that is wanted. If this is not obtained, short-circuit the terminals 3 and 4 by a piece of wire or metal of any kind ; if a deflection is now obtained, it proves the fault is in the receiver or leads.

Repeat by short-circuiting on terminals on back of receiver ; if no deflection it proves a break in the receiver leads.

If there is a deflection it proves a break inside receiver. If a fault is still on, open the middle partition and trace out circuit carefully.

Care should be taken when connecting the hand telephone to the instrument to join the *long red* lead to No. 1 terminal, *short red* to No. 2, short brown to No. 3, and long brown to No. 4.

This instrument is very handy and portable, but is not suitable for use in wet weather in the field, nor are the parts inside the box easy of access.

Telephone, Portable, "C," Mark II.

Rough tests—

(*a*) *To test bell circuit.*—Disconnect line wires, turn handle of generator, bell should ring ; short-circuit line terminals, bell should not ring.

(*b*) *To test speaking circuit.*—Disconnect line wires, close pressel switch, taking care that it is pressed well home, blow into transmitter, sound should be heard faintly ; short-circuit line terminals, sound should be distinctly heard.

Tests in detail—

If (*b*) fails.—(i) Test primary circuit by breaking at M1 and inserting low resistance coil of a detector, there should be a deflection only when the pressel switch is closed.

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(ii) To test secondary circuit, place a battery of two cells and high resistance coil of detector in series with line terminals, disconnect M1, close pressel switch, and there should be a good deflection, and only a slight deflection when switch is released.

If either of these tests fail, proceed as previously detailed.

NOTE.—There is a double contact in pressel switch, the first contact closes the secondary, and the second closes the primary circuit.

In testing the primary circuit, care should be taken to see that the second contact is made.

Listen for sounds in the receiver with pressel not pressed. If sounds are heard the pressel is short circuited and requires adjustment.

To remove tray from box, remove back and disconnect M1, R1, and R2, remove the terminals to which lightning protectors are joined, also handle of generator. The tray should then slide out easily.

THE 5-LINE CONCENTRATOR.

Rough tests—

(*a*) *To test call circuit.*—Turn handle of magneto generator, the pilot bell should ring if connected up.

Disconnect pilot bell and connect the bell terminals on the concentrator by two short leads to each pair of line terminals in turn; each indicator should drop when its line terminals are connected up and the handle of generator turned.

If one or two indicators out of the number do not drop, they are out of order, probably mechanically.

If none drop, the fault is probably in the magneto.

(*b*) *To test the speaking circuit.*—Disconnect line wires (one pair at a time, and label them to avoid confusion) and the

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pilot bell; place keys in speaking position, close pressel switch in hand telephone, blow into the microphone, sounds should not be heard. Now short-circuit each pair of line terminals in turn, and again blow into microphone, sounds should be heard.

Tests in detail—

If the sounds are not heard, test primary circuit by inserting the low resistance coil of a detector at terminal "M. I.," close pressel switch, when a deflection should be obtained; if not, the fault is somewhere in the primary, and must be located.

If the primary circuit is correct, test the secondary by turning the handle of the generator, and close pressel switch in the hand telephone, when the currents then generated should be heard in the receiver.

If sounds are not heard in the receiver, test the circuit throughout with a detector and a battery of two cells.

If a fault is suspected in line (having ascertained that both instruments are in good order) communication must be established with distant operator. Disconnect both telephones from line. Then :—

i. Instruct distant operator to insulate one of his lines, and put a battery and the high resistance coil of a detector between the lines at the home end. There should be no deflection. If there is, line is short-circuited.

ii. Instruct distant operator to short-circuit his line wires, and there should be a good deflection on detector; if none, then line is broken.

The tests for line can also be carried out with telephones portable A and C, Mark I, using the magneto and

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bell instead of a battery and detector, the receiver being kept on the hook.

122. *Telephone attachment with horizontal P.F's.*

For method of using the telephone attachment with horizontal P.Fs. and tests of that instrument *see* "Manual of Coast Defence Range Finding, Part I."

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CHAPTER XI.

RANGE-FINDERS AND CLINOMETERS.

123. *General.*

1. **The accuracy of long range fire will depend to a great extent on the correct adjustment and use of the range-finder.**

Lieut.-colonels commanding are responsible for the efficiency of all range-finding instruments in their command.

2. The following range-finders are used in coast defence :—

i. Watkin's position-finder (P.F.).
ii. Watkin's depression range-finder (D.R.F.).

A few Barr and Stroud range-finders are also in the service.

For details and drills *see* "Manual of Coast Defence Range Finding."

For "Examination in Range finding" *see* Appendix III.

124. *Position finders.*

1. Position finders are supplied for the use of 9·2-inch B.L. guns and upwards, and may also be found installed for the 6-inch guns in some stations. They may be divided into two classes :—

Depression instruments.
Horizontal instruments.

2. Depression instruments are only employed when the height available is sufficient to obtain the range required by

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the gun they serve. Those of the latest pattern are graduated up to 20,000 yards, but, unless they are placed at great heights, their readings at this range will not be very reliable. The minimum height at which reasonable accuracy may be expected may be taken roughly as 100 feet for every 5,000 yards of range.

3. Horizontal instruments similarly graduated are employed on low sites where accuracy can only be obtained by use of a horizontal base. They are sub-divided into two classes :—

i. Long base instruments.
ii. Short base instruments.

With the former the base should be over 2,000 yards, with the latter it should be between 500 and 1,000 yards.

Both classes may be employed as depression instruments for short ranges ; thus with about 20 feet height, ranges up to 2,000 yards may be obtained with fair accuracy, provided the sea be fairly calm, and other conditions favourable. Longer ranges may be obtained from greater heights.

With horizontal instruments it is not necessary to lay on the waterline, and they will therefore often be of the utmost value if—as may sometimes be the case—the attacking ships are so enveloped in smoke and spray that the masts, funnels, &c., are the only definite points to lay on. In such circumstances, depression instruments would be useless.

4. *Advantages.*—When correctly set up, it is the most accurate means of range-finding, and is not liable to get out of adjustment. Its position is in no way dependent on the site of the battery ; it can, therefore, be easily concealed and advantage can be taken of the highest ground for its position. It measures the range to the target from the gun for which it is set up. It gives the training from the gun,

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so enabling the gun to be laid by Case III. Guns can thus be fought, when P.F.'s are well to a flank, in spite of dust and smoke caused by enemy's shot and shell. Both range and training dials are actuated by the working of the instrument, delay is thus avoided and errors are eliminated.

5. *Disadvantages.*—It is not portable, it is very expensive, its mechanism is complicated and involves several electric circuits and numerous wires and cables which require constant examination and care. It can only be used as a P.F. for the group for which it is set up. Its position is generally at considerable distance from the B.C.'s post, and orders have to be sent to the operators by telephone or signalling, causing delay and possibility of errors. With the horizontal instruments a difficulty sometimes arises in getting the two observers at each end of the base on the same target. Occasionally, owing to smoke or haze, the target may be visible to one of them only.

125. *Depression range-finders.*

1. Depression range-finders are allowed for 4·7-inch Q.F. guns where employed as medium armament, and for 6-inch B.L. guns Mark VII and upwards.

2. The telescope is of about the same power as that of the P.F., and hence, under similar conditions, equal accuracy should be obtainable. This, in practice, is seldom the case, probably owing to the fact that the D.R.F. is removable, whereas the P.F. is permanently installed, and is also mechanically a superior instrument.

While the D.R.F. is in close proximity to a group, the training as well as the range of a target may be communicated to the guns, though this method cannot well be used with a quick moving target. The scale on the base plate of the instrument is set to the same meridian as the traversing

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arcs of the guns, and the training of the target read by its means.

3. *Advantages.*—It is portable, comparatively cheap, simple in construction, and can easily be repaired or adjusted. Its use is not restricted to any particular group, and it can be set up in the position considered most suitable for the B.C.'s post.

4. *Disadvantages.*—It is less accurate than the P.F. and gets out of adjustment more easily.

It only measures the range to the target from its own position, thus often necessitating group or gun differences. (*See* Appendix II., Sec. **3.**)

Height of site may be limited on account of the desirability of keeping the instrument close to the battery. This also entails risk of damage to instrument and detachment, and possibility of target becoming obscured by dust and smoke.

Three men may be necessary to take ranges and pass them to the guns, therefore errors may occur.

126. *The Barr and Stroud range-finder.*

1. This instrument is a "one observer" instrument with horizontal base, and depends in principle on rays reflected through prisms at either end of the tube which forms the base.

2. *Advantages.*—It is portable and simple to work. It measures ranges from a fixed horizontal base and can therefore be used at any height and requires no levelling or datuming points. It is a one-observer instrument, therefore errors inherent in many horizontal base instruments are eliminated. It is very simple and easy to learn. It has no micrometer screws or easily wearing delicate parts. It does not easily get out of order and can be readily re-adjusted.

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Range finding with it is as easy and accurate at night as in the day time. When properly adjusted it will work to an accuracy of nearly 98 per cent. at 5,000 yards range, and in this respect compares very favourably with D.R.F. and Depression P.F. from heights below 50 feet.

3. *Disadvantages.*—It is only accurate up to medium ranges. Gun differences will be as necessary as with D.R.F., hence it will be desirable to keep the instrument close to the battery, involving risk of damage, &c.

127. *Means of passing ranges, trainings and orders.*

1. Ranges and trainings are passed from P.Fs. to the guns they serve by means of electrical dials actuated by the instruments themselves. These dials in most modern batteries are placed in convenient positions on the mountings, and are provided with movable faces which enable range and training corrections to be applied.

2. Ranges are passed from D.R.Fs. to the guns by means of :—

i. Mechanical dials, which actuate the electric range dials on the gun mountings.
ii. Range indicators.

3. Order dials are used in certain works for transmitting orders from the B.C. post to the guns.

4. For description of the adjuncts mentioned above and instructions as to their use, *see* "Manual of Coast Defence Range Finding, Part I."

128. *Clinometers.*

1. *Clinometer, Watkin's, Large.*—The brass drum is marked in degrees, commencing at 0° on the top to 45° at the bottom.

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Each degree is subdivided into 12 divisions, each division representing 5 minutes.

A reader, graduated to read single minutes, is engraved on the index plate. As the divisions on the drum vary slightly in dimensions, it will be sometimes found that the 5 minutes' graduation on the index plate does not quite coincide with a 5 minutes' division on the drum. The latter, however, having been graduated by actual testing, will be taken as correct. The divisions on the index plate, in this case, will still assist the eye in determining the exact setting.

The scale is read from right to left, thus—

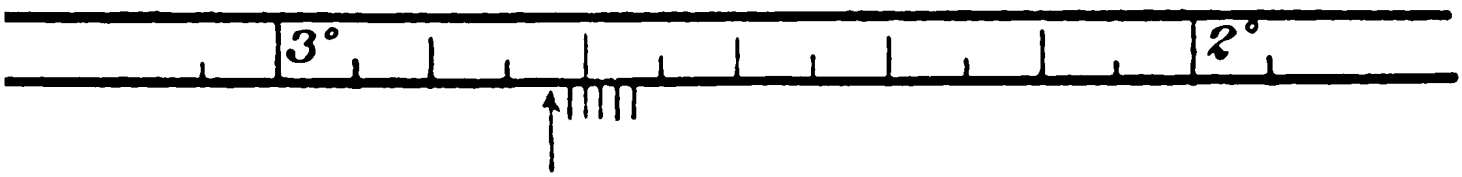

Fig. 9.

the reading opposite the arrow would indicate an angle of 2° 42′.

2. When using the clinometer great care should be taken that the clinometer plane on the gun is clean and free from paint. The bubble should be shielded from the direct rays of the sun when the instrument is in use.

3. *To lay a gun to any angle up to* 45°.—Unscrew the drum until the ↑ points to the elevation required, place the clinometer thus—

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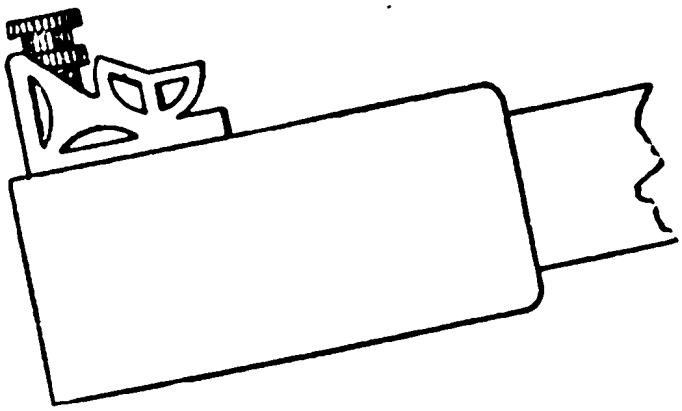

Fig. 10.

on the plane surface cut on the gun, and elevate the piece until the bubble of the spirit-level is in the centre of the tube.

4. *To lay for Angles of Depression.*—Proceed as above, but reverse the direction of the instrument, placing it on the gun thus—

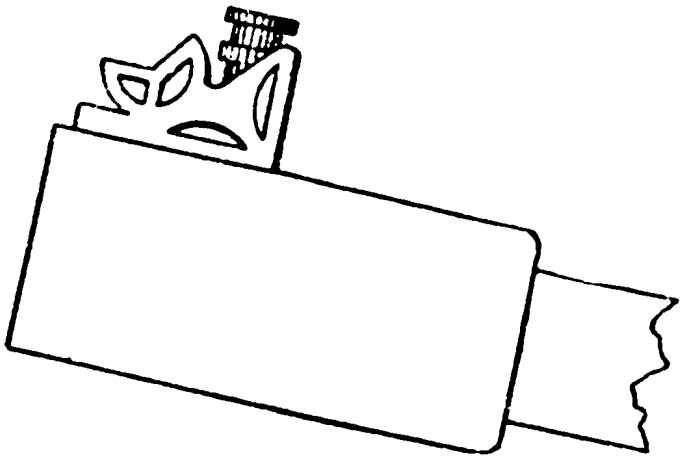

Fig. 11.

5. *The Clinometer, Inspector's.*—This is used in a similar manner to the clinometer, large. It is graduated in half

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minutes up to 25°, and is capable of considerable accuracy. It should not be used on its short face.

6. *Preservation and adjustment of clinometers.*—In order to preserve a clinometer in efficient working order, it is necessary to keep the working parts free from grit and dust as far as possible. As excess of oil is apt to cause the adhesion of grit, only sufficient is to be applied to make the screw work smoothly, and to keep the steel parts from rusting.

7. On no account should the instrument be taken to pieces, as it requires special tools to put it together again.

Instruments are issued in correct adjustment, and with due care will remain correct for many years.

8. To test the zero of the instrument :—

i. Carefully clean the plane surface cut on a gun for use with the clinometer.

ii. Turn the drum to zero.

iii. Place the instrument on the plane surface, drum towards the rear, mark the position of the instrument on the plane, and elevate or depress the gun till the bubble is in the centre of its run.

iv. Turn the clinometer end for end, taking care to place it on the same part of the plane as before.

v. Should the bubble not return to the centre, the instrument is out of adjustment.

vi. As the amount of the error will generally be small it is advisable to add or subtract the error, as the case may be, rather than correct the adjustment.

vii. To ascertain the error after complying with iv, turn the drum until the bubble is again in the centre of its run ; one half the reading on the drum is the index error. What is practically a new zero point on the scale is thus determined.

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viii. If the reading falls on the black markings on the drum, add the index error when setting the clinometer for any required elevation. Subtract the index error when taking a reading with the clinometer.

ix. If the reading falls on the red markings on the drum, subtract the index error when setting the clinometer to give elevation ; add it when taking a reading.

9. If it is required to adjust the clinometer to have no index error, set the drum to the ascertained index error, and bring the bubble to the centre of its run by elevating or depressing the gun. Then, placing the drum at zero, manipulate the capstan-headed nuts (using a tempered steel wire just fitting the holes in the nuts), till the bubble is in the centre.

Reversing the instrument end for end should not alter the central position of the bubble ; should it do so, proceed as before until there is no change.

10. Every clinometer should be tested against a standard inspector's clinometer, and record should be kept of the errors of the instrument and the corrections to be applied at various angles when extreme accuracy is required, as when testing automatic sights.

These corrections, which are due to inaccurate graduation, are additional to, and independent of, the index error which is due to faulty adjustment.

The records should be so worded as to make it clear how the clinometer must be set to give any angle required.

11. The angular deviation between the axis of the bore at the muzzle and the clinometer plane should be allowed for when laying a gun by clinometer. The deviation should be

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found recorded in the Memorandum of Examination of the Gun as "Up" or "Down," according as to whether the muzzle is inclined up or down with relation to the clinometer plane.

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CHAPTER XII.

CARE OF EQUIPMENT, AND ADJUSTMENT OF SIGHTS.

129. *Duties of personnel.*

1. Company officers in charge of armament sub-districts are responsible for the care, preservation, efficiency, and cleanliness of the armament, ammunition and stores in their sub-district, and nothing in this section must be held to absolve them from any part of such responsibility (*see* "Notes on Artillery Store Accounts").

2. The master gunner is responsible for the custody and issue of stores of all kinds. His position in action is at the artillery store of the portion of the armament under his charge.

3. Artificers are detailed according to local requirements and are under the immediate control of the Inspector of Ordnance Machinery. Their duties are the care and preservation of the gun mountings, and of all mechanical details connected with the fort.

4. District gunners are immediately responsible to the master gunner for the care and cleanliness of the guns, mountings, stores, &c., placed in their charge. They should have an intimate knowledge of the gun under their care, its mounting, and all stores connected with it, and also of the storage and means of supply of the ammunition for the same

As a great deal of the daily routine work of a district gunner has to be performed without constant personal supervision, especially where the guns of a master gunner's charge

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are much scattered, it is most desirable that they should be reliable men, and that they should not be changed frequently.

The duties, both generally and in action, of district gunners, as well as the number required for each work, should be defined locally.

130. *Tools and material.*

The allowance of tools and materials for keeping Artillery Matériel in good repair will be found in Equipment Regulations, Part II, Section XII (*a*).

Detailed instructions for the care of Armament and Stores are given in "Regulations for Magazines and Care of War Matériel." See also "Manual of Coast Defence Range Finding."

The instructions in Secs. **131** to **133** should be known by all N.C.Os. and first class gunners.

131. *Guns.*

1. The bright parts of guns will be oiled and if not in frequent use will be covered with red mineral jelly. The bores will be kept cleaned and oiled, or, in the case of dismounted guns, coated with a mixture of mineral jelly and beeswax, when not in frequent use.

2. Before firing, the mixture of mineral jelly and beeswax and oil will be removed.

After firing powder the bore will be washed, and as soon as dry will be oiled with a greasy cloth or piece of old linen tied over the piasaba brush.

After firing with cordite charges the bore will be thoroughly washed out and, when dry, coated with red mineral jelly.

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After using an aiming rifle or sub-calibre gun in a gun, the bore of the latter will be thoroughly cleaned as soon as possible after the aiming rifle or sub-calibre practice and before service ammunition is fired from the gun.

3. Guns will be depressed to prevent rain or moisture lodging inside, the muzzle and breech ends being protected by covers.

4. As a general rule all B.L. and Q.F. guns under 6-inch calibre, when mounted in exposed positions and not in frequent use, will have all fittings removed.

Guns of 6-inch calibre and above will have the smaller fittings removed, but the axial vents and the obturators will be left in the gun. Guns having slow coned obturators will have the axial vents and obturators removed also. Fittings will be kept in store, the steel portions coated with mineral jelly.

Fittings remaining with the guns will be treated in a similar manner.

In the case of guns used for drill and practice all fittings must be kept free from dust and grit and all working parts well lubricated.

5. The first time an obturating pad is used in any particular gun it should be with a full charge and projectile.

Obturating pads when not in the gun will invariably be kept under compression, properly assembled with their discs, in the special boxes provided for the purpose.

6. The pad and protecting discs should be carefully examined, and in case the pad is cut or the discs or steel rings fuzed, eroded, burred, or cracked, the complete obturator and discs should be replaced as a whole by the spare pad and discs.

If the tin is found to have expanded over the circumferential portion of the steel ring of the rear protecting disc,

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the expanded tin should be filed away, care being taken not to reduce the diameter of the steel ring.

132. *Mountings.*

1. A thorough cleaning and lubricating of all standing working parts must take place once a month, clotted grease being removed by scraping. Mountings much exposed and liable to accumulate dust or sand should not be left with much grease or oil upon them, but only sufficient to prevent rust, for which a very slight film will suffice.

2. Special care must be taken to prevent grit from getting on the sliding surfaces of all guns mounted in cradles.

Before applying fresh lubricant the old should be scraped or wiped off. The parts should be worked to distribute the fresh lubricant before leaving them.

Friction cones, brake drums, and discs of friction clutches, will be kept clean, smooth, and very slightly oiled to prevent seizing.

3. In lubricating, the lubricating holes will be cleaned out with a wire and filled with oil, care being taken to replace the small screws, the heads of which must be kept bright so as to be easily seen. After filling the oil holes the parts should be worked backwards and forwards until the oil shows on the shafting, fresh applications of oil being made if necessary.

4. A nut or screw should be slightly oiled before being entered and a few turns given by hand before using the spanner. A hammer should never be used to tighten up screws or nuts.

5. Particular attention will be observed when removing or adjusting any gear not to indent or damage component parts by rough usage. A hammer should never be used unless with a piece of wood or brass to transmit the blow.

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6. It is most important that grit and dust should be prevented from entering hydraulic cylinders. After drill or practice a well oiled twist of tow should be bound tightly round the ram close to the bush of the cylinder and left there till next working, when it should be carefully removed with the dust adhering to it. Any grit or dust on the ram during the firing should be at once removed.

The leathers and packing must be preserved in good order, the cylinders therefore should be kept filled with the proper charge of liquid and under full working pressure.

7. With the Barbette B.L. 9·2-inch Mark V, the pressure in the air cylinder should be taken once a week to see if loss occurs and care should be taken that the intensifier is kept fully charged. Once a week the mounting should be traversed through its arc of fire, and elevated and depressed; the accumulator should be pumped to its highest point and the front and rear hoists run.

The accumulator, when not in use, should be pumped up 1 inch from bottom stop and the valve to gun pressure slightly opened. This will keep pressure on all leathers and glands.

133. *Sights and telescopes.*

1. Sights should be kept clean, oiled, and free from grit. They should on no account be polished.

2. When not in actual use the telescope, the sight bar, and other fittings attached, are to be removed and placed in a dry store. The removal of the sight bar can be effected by removing a nut and washer, which will be found under the pivot.

3. With the auto-sight, the efficiency of the sight depends upon the accuracy of the cam and roller. Special care must be taken that they receive no damage. They must on no

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account be polished, but kept clean and free from grit or dust, by wiping with a clean rag moistened with a few drops of oil.

4. All parts are to be kept clean, working parts well lubricated with clean oil, and (with the exception of the cam groove and roller) lightly smeared with anti-corrosive grease when not in use. Bath brick, emery, or other abrasive substance must not on any account be used for cleaning.

5. The sight gear should not be taken apart unnecessarily, and no adjustment made by scraping or filing except on special authority.

6. In throwing the latch of a combined sight into gear, care should be taken that it is opposite the jaws in the cam roller lever, in order to avoid injury to the parts.

7. The exterior surfaces of telescopes are to be cleaned with a soft rag and paraffin only. The exterior surfaces of lenses should be cleaned with chamois leather, which must be kept perfectly clean and dry and used for this purpose only.

8. The bearing surfaces of sighting telescopes must be very carefully protected. Any burrs or dents on these surfaces throw the telescope out of adjustment.

9. Telescopes must not be taken to pieces, the lenses removed, or adjustment for collimation attempted, except by a competent person. When not in use they should be closed up, caps replaced, and placed in their cases. They should be kept in as dry a place as possible.

134. *Testing sighting telescopes.*

1. The telescope is focussed for individ ual eyesight by revolving the eyepiece until the pointer is clearly defined. As with these telescopes changes in focal distance due to change of range are inappreciable, no means of focussing

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the object glass are provided. The pointer is placed at the focal distance of the object glass, and both it and the distant view should become clear at the same time. An inverted image of the distant view is formed at the focal distance of the object glass.

2. To test if the pointer is at the proper distance from the object glass, focus it with the eyepiece, and then lay so that a very small bright space is left between the tip of the pointer and some object ; now move the eye behind the eye-piece, and note if the bright space vanishes or changes size. If this is the case, the pointer has shifted position. An inaccuracy, called parallax, will then be caused by changing the position of the eye, and, as both pointer and distant view can no longer be focussed together, the eye will be strained and will tire rapidly. Telescopes found wrong in this particular should be reported, and sent for adjustment by a properly qualified officer.

3. Telescopes are issued, and should as a rule remain, correctly collimated. To test for collimation, the telescope is placed in its holders, focussed, and then directed on a well-defined object not less than 400 yards distant. When the telescope is turned round in its brackets, the tip of the pointer should not move off the point laid on. Care should be taken that in carrying out this test movements of gun are not mistaken for movements of pointer. Telescopes found out for collimation must be adjusted by a properly qualified officer. In some cases the brackets in which telescopes rest become bent, and it may then be found that the telescope alters position when its brackets are clamped or unclamped. For procedure in the case of rocking bar and automatic sights respectively, *see* Secs. **135** and **139**.

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135. *Testing and adjusting rocking bar sights.*

1. Lay the gun horizontal by means of a clinometer, place the "bar, testing sights," in the Y brackets, getting the marks on it and on the bracket to coincide so as to get correct cross level; bring the rocking bar to angles of depression corresponding to the tangent elevations for various ranges corrected for the height of the telescope above the axis of the gun, by working the hand wheel, and see if these ranges are read off on the sight drum. If this is not the case, slacken the screws on the outer circumference of the range drum, and turn the scale until the correct range is read.

2. Or the sight may be datumed at M.S.L. on a datum post by giving the requisite Q.E. to the gun by clinometer, and turning the range drum of the sight till the telescope pointer is on the water-line of the datum. The range drum should then read the true range to the datum. If it does not, adjust as in 1. This is the most satisfactory adjustment in the case of the telescope brackets being bent.

3. To test for deflection, lay the gun on a distant mark, obtaining a line of sight through the axial vent (or firing hole bush) and the intersection of two fine cords stretched on the axis lines on the muzzle. The sight, with elevation and deflection set at zero, should be on the same mark. If it is not, bring the sight on to the mark with the deflection gear and adjust the reader of the deflection scale to zero.

136. *General instructions for testing and adjusting automatic sights.*

1. The auto-sights of all guns will be tested annually by an Inspector of Ordnance Machinery or by an officer deputed specially for that purpose by the Superintendent, Royal Carriage Department. The tests will be such as are

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prescribed for the original setting up of the sight, and, if necessary, the sight and cam will be re-set.

A test will be made of all cams, whether for full or reduced charges, or for aiming rifles.

2. Verticality of pivot and truth of correcting gear will be tested, and, if necessary, adjusted, at the same time by the same officer.

A certificate from this officer that he has personally set up the sight, and that it is in correct adjustment, will be furnished to the C.C.D. An entry showing date, and by whom tested, will be made on a form provided for the purpose.

These tests should be carried out before the first series in the annual practice is fired from the gun.

3. If the sights cannot be set up true for all ranges up to the extreme limit of range, and the cam cannot conveniently be returned to be trued at the Arsenal, the I.O.M. will furnish a table showing the errors at each angle on the Woolwich table of angles. This table will be filed with the Woolwich table of angles. In the case of guns used solely for anti-torpedo-craft defence the limit of range will depend on the extent of the illuminated area.

4. After testing, the eccentrics on the carrier will be painted over, and will on no account be interfered with, except by an I.O.M. or R.C.D. artificer.

With the above tests and adjustments, the responsibility of the I.O.M. or Carriage Department with regard to the sights ceases, except as regards telescopes sent for collimation or focussing, or sights which, for any reason, may again require to be set up during the year.

5. **Officers in charge of the guns are responsible for the care and preservation of the sights, and for such tests and adjustments as can be carried out without the assistance of a skilled artificer.**

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All officers should be able to carry out the tests, and such adjustments as do not require the assistance of artificers.

6. "Clinometers, large," should be used for adjusting automatic sights, "Clinometers, Inspector's," being kept as standards. When placing the "bar, testing sights," in the telescope brackets, the marks on it and on the brackets should coincide, thus getting correct cross level.

7. The gun must be balanced as if loaded, and must always be brought into position by a large sweep of depression; the latter rule must also be observed when firing.

In the case of a mounting with sighting steps, it must be balanced by keeping men in the positions of the layers and setter during the test.

8. When setting the "error of day" drum, both for testing or putting on corrections, the final movement given should be one for "lengthen."

When setting the "tide lever" the last movement should be in the direction of "fall."

9. Cams will be changed as seldom as possible. Guns should, however, usually be fitted with the full charge cam, and in any case a full charge cam must be fitted and tested annually.

Whenever a change is made from one cam to another, and always in preparing for action, the sights will be carefully tested by the G.G.C.

Unnecessary adjustments of eccentrics should be carefully avoided.

137. *To test verticality of pivot with auto-sights.*

1. With guns of which the sights cannot be corrected for want of level independently of the rest of the mounting:—

Place clinometer on gun and bring bubble central.

Traverse through 180°, halting every 30°. The bubble

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should return to the same position each time the gun is halted. The training of maximum tilt and the amount the pivot is out of the vertical can be determined by this test.

2. Means are provided with certain guns for correcting the sight independently of the rest of the mounting. With guns thus fitted, the bubble of the spirit level on the cam should come to the same spot, no matter in what position the gun is halted.

An alternative test is to place a clinometer on a "bar, testing sights," in the telescope brackets and traverse through 180°, halting every 30°. The gun should be brought horizontal each time, and the angle of depression of the sight should then always be the same. If rapidity is necessary, and the pivot only slightly out of truth, this test may be modified by giving the gun extreme elevation; small movements of the gun, due to want of level, would have then an inappreciable effect on the sight, and the elevation of the gun need not be attended to during the test.

3. Adjustments for verticality of pivot require the services of an artificer.

4. If it is necessary to use auto-sights before the mounting can be restored to level, the next test should be carried out in the middle of the arc of fire.

138. *Mechanical test with auto-sights.*

1. Set the "error of day" drum and deflection scale at zero, and tide lever at mean sea level, and clamp the "bar, testing sights," in the telescope brackets; also, if the sight is a combined one, throw the catch into the fork. With 12-pr. Q.F. the trunnions should be clamped. From the Woolwich table of angles, supplied with each auto-sight, select a suitable range; bring the gun to the corresponding Q.E.; the angle of depression of the sight should now be

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the one corresponding to this range. For guns used at night the range selected should be as near the Test Range as possible.

2. The Test Range for guns used at night is the range when the attack develops. This is the range to the leading vessel at the time it has just entered the illuminated area, or, in the case of guns provided with fighting lights, when first adequately illuminated by such lights.

The Test Range must not be beyond the accuracy limit of the auto sight. (*See* App. II, Sec. **18.**)

3. If the depression angle is not correct, it must be made so by turning the eccentric connected to the error-of-day drum, after first slacking its clamping nut, or by turning the error-of-day drum and noting the reading, which will be taken as the zero for subsequent settings. In some cases this adjustment is carried out by turning the error-of-day drum, after which a movable skin is adjusted to read zero.

The sight should then be set to extreme deflection each way in turn, and the bubble of the clinometer should not move. If it does, the services of an artificer are necessary.

4. If time is available, this test may be repeated for every range in the table of angles; if, after adjusting the sight for one of these ranges, the remaining readings are incorrect, the eccentrics on the carrier require adjustment; for this, the services of an artificer are necessary.

For guns used at night these tests will be carried out at ranges on each side of the Test Range; the sight may be considered correct provided that no test within 500 yards of the Test Range shows an error greater than that corresponding to one minute of Q.E. The permissible error in the depression angle of the sight will therefore be $\frac{a}{a+\beta}$ minutes. (*See* App. II, Sec. **13.**)

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5. In carrying out this test, where local conditions make it certain that the variation of range during action with auto-sights will be small, the quadrant angles shown in the Woolwich table of angles should be first corrected for the variation of the M.V. of the gun from the normal M.V. for which the cam is cut.

Such cases are—

(*a*) Guns mounted on low sites, when the effective limit of auto-sights is under 3,000 yards.

(*b*) Guns used for the defence of narrow channels, the shape of which makes big variations of range impossible.

(*c*) Guns used at night, when the range of the guns is limited by that of the lights.

(*d*) Anti-torpedo-craft guns.

When this method is employed, the range selected for the test must be approximately the same as the Test Range.

It must be clearly understood that the alteration of the Woolwich table of angles makes the sight inaccurate at all ranges other than those near the Test Range, and that therefore this method must be strictly limited to guns which will only use the auto-sight under the conditions given above.

139. *To test for bend in Y brackets.*

In some cases the brackets in which a telescope rests become bent, and it may then be found that the telescope alters position when its brackets are clamped or unclamped.

In this case the sight should first be laid, with the brackets unclamped, on a fixed mark. Remove the telescope, place in the "bar, testing sights," and take the depression angle of sight by clinometer.

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Then clamp the brackets and note whether the clinometer bubble remains central. If it does not, bring it central by the error-of-day drum and note the reading. Then remove the "bar, testing sights," move the error-of-day drum back to zero, replace the telescope, and clamp the brackets.

If the pointer is not on the fixed mark bring it on by means of the error-of-day drum and note the reading. If the readings are alike no compensation is needed. If the readings are different an adjustment of the eccentric connected with the error-of-day drum is required, the drum being set at the reading as found when using the "bar, testing sights," and the telescope pointer being brought on to the object by means of the Q eccentric.

In clamping up the Y brackets care should be taken to tighten the clamps simultaneously, as if tightened separately variations in readings will occur according to which clamp is bent.

140. *To test the zero of deflection scale with auto-sights.*

1. In the case of guns fitted with rocking bar and auto-sights, the former is tested for line as described in Sec. **135**, and the latter is then checked with it by laying with the auto-sight on a distinct mark on the water. If the deflection scales of the two sights do not now read alike, that of the auto-sight must be made to agree with that of the rocking bar.

2. When guns have auto-sights only, the sight must be tested with the bore of the gun, but the mark must be near enough to allow both gun and sight to be laid on it for line and to eliminate most of the drift correction which is automatically applied on the sight.

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141. *To datum a sight.*

1. It is desirable to have a false datum mark to which the angle of depression is the same as that of the Test Range at mean sea level.

A false datum mark is generally preferable to a waterline datum when datuming automatic sights, as the operation can then be carried out for mean sea level at all states of tide ; also inaccuracies due to waves are eliminated.

Such a mark should not be less than 400 yards from the gun or the telescope will be out for parallax.

Failing this a natural mark should be selected at a range as near the Test Range as possible.

2. From the datum slide rule or table of Q.Es. ascertain the Q.E. necessary for calibration M.V., allowing for charge temperature, and, if necessary, for rise or fall of tide, and for raising M.P.I.

All breech fittings should be on, shell and cartridge in the bore, and, with 6-inch guns, all layers and setters on the sighting steps ; this balances the gun exactly as for firing.

Set the tide lever, test the clinometer for index error, and then lay the gun at the required Q.E., taking care that the last motion is one of depression.

If the tip of the pointer is now found to be very nearly on the datum mark, it should be brought exactly on by means of the error-of-day drum or clicking indicator, taking care that the last motion is one of lengthen.

If it is not very near, slack off the locking nut of the eccentric bouche Q, raise the pointer well above the datum mark by turning the eccentric bouche Q, and then bring it down nearly as far as the mark ; tightening up the locking nut will give the pointer a further motion of depression, and only constant practice will train a layer to judge the final

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amount of depression obtained by tightening up the locking nut.

3. After adjusting the sight, the layer must lay the gun at least three times by the automatic sight. If the bubble of the clinometer, set to the required Q.E., comes central each time, the sight is satisfactorily datumed.

If the bubble does not come central each time, adjust on the error-of-day drum or clicking indicator, and again try the three lays.

Not till three consecutive lays are correct can the sight be said to be properly datumed.

4. In datuming, errors of collimation are automatically corrected. Once the sight has been datumed, the telescope must on no account be shifted in the Y-brackets; if it is moved at all, a considerable error may be introduced, due either to worn Y-brackets, worn telescope bearings, or both.

5. *To determine the position for the false datum mark.*—Calculate the depression angle for the Test Range (*see* Sec. **138**), taking into consideration the height of the axis of the telescope above the trunnions, and the necessary correction for curvature and refraction. See that the pivot of the mounting is vertical, and that the telescope is in correct adjustment for collimation and parallax. Set the sight to the above depression angle, traverse on to some object, and paint a mark thereon in line with the pointer of the telescope. If no natural object is available a post should be erected.

A convenient mark may be used, should one exist approximately in line with the pointer of the telescope, but in this case the range corresponding to the depression angle to this mark must be calculated (*see* Appendix II).

In selecting a position for a false datum care should be taken that there is no ground, such as sand, &c., between

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the gun and the mark, which might cause variations in refraction.

142. *Backlash of sight.*

1. The sight should occasionally be tested by bringing it to a certain angle, first by a wide sweep of depression, and then by a wide sweep of elevation, and noting the difference between the readings of a clinometer on the gun on each occasion. This should be done at angles corresponding to three or more widely different ranges.

2. When a considerable discrepancy is found between readings the sight requires overhauling. This will most frequently occur with combined sights. These sights require testing, both as auto-sights and rocking bar sights.

143. *Tests with elevation indicator.*

1. Verticality of pivot should be tested as in Sec. **137** (1).

2. Since the elevation indicator indicates the elevation of the gun relatively to the mounting, it follows that any inclination of the latter will cause an equal angular error in quadrant elevation. The error will be − or + according as the tilt of the mounting is to the front or rear.

3. The proper correction can be applied at any one training as follows :—Lay the gun by clinometer at the Q.E. for a selected range, and adjust the elevation indicator to read the proper range. This adjustment should be made at the training where there is no tilt or at what is considered the most important training in the arc of fire as decided locally, and the elevation indicator should always be tested at the same training.

4. For further consideration of the effect of tilt and corrections required *see* App. II., Sec. **5.**

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APPENDIX I.

Solution of Triangles and Use of Slide Rule.

1. *Trigonometrical ratios.*

1. Let two straight lines meet, making an angle A with one another. Take any point in one of the lines and from it draw a perpendicular p to the other line. A right-angled triangle will thus be formed. Call the hypotenuse h and the third side or base b (Fig. 12).

The ratio p/h is called the sine of the angle A or sin A.
„ p/b „ tangent of the angle A or tan A.
„ b/h „ cosine of the angle A or cos A.

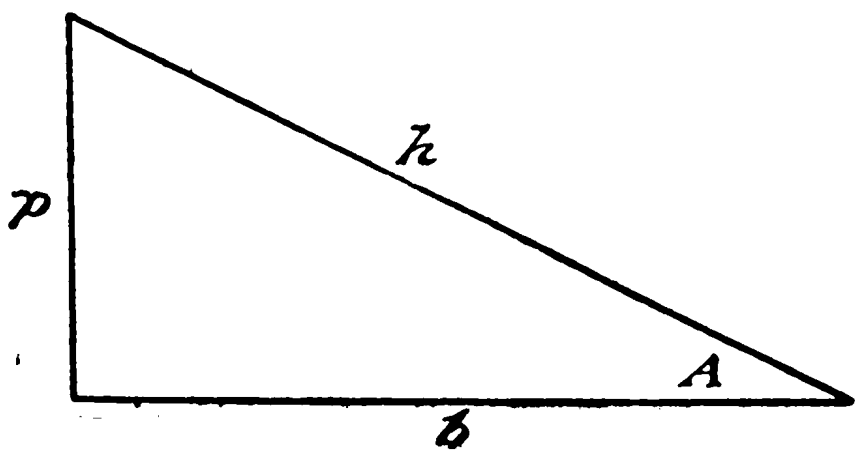

Fig. 12.

2. The above ratios are called the trigonometrical ratios, they are constant for any angle. Some are so simple and

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occur so frequently that they are worth remembering. They are :—

	0°.	30°.	45°.	60°.	90°.
Sine	0	$\frac{1}{2}$ = ·5	$1/\sqrt{2}$ = ·71	$\sqrt{3}/2$ = ·87	1
Tangent	0	$1/\sqrt{3}$ = ·58	1	$\sqrt{3}$ = 1·73	Infinity
Cosine	1	$\sqrt{3}/2$ = ·87	$1/\sqrt{2}$ = ·71	$\frac{1}{2}$ = ·5	0

3. In the case of very small angles the hypotenuse and base become very nearly equal and consequently the sine and tangent become very nearly equal also.

For practical purposes it may be taken that the sine and tangent are equal in the case of angles not exceeding 6°.

The complement of an angle is that angle which must be added to it to make it equal to a right angle. Thus the complement of A is $90° - A$. It is evident that in a right-angled triangle one of the acute angles is the complement of the other and that the sine of an angle is the cosine of its complement.

The supplement of an angle is that angle which must be added to it to make it equal to two right angles. Thus the supplement of A is $180° - A$.

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It is useful to remember that in magnitude the trigonometrical ratios of angles and of their supplements are equal, *e.g.*,

$$\sin 94^{c} = \sin (180 - 94^{\circ}) = \sin 86^{\circ}.$$

2. *The range finding formula.*

The sine of 1 minute = 1/3438, and when m is a small angle

$$\sin m \text{ minutes} = m/3438.$$

Therefore, in fig. 41, if the angle A be m minutes

$$p = h \text{ feet.}$$
$$h = \text{R yards.}$$

We have $\sin A = m/3438 = h/3R.$

$$\therefore m/1146 = h/R.$$

This is generally known as the "Range-finding formula. It may be considered practically accurate up to 6°, when m as given by the formula is about half-a-minute too little. With larger angles the errors are greater.

3. *Use of the slide rule.*

1. The rules for setting the slide rule in simple cases are given below.

2. *Multiplication.*—Place 1 on the slide opposite one factor on the rule, and opposite the other factor on the slide will be found the product on the rule.

Either the two upper or the two lower scales may be used, but it is preferable to use the lower ones, as the graduations are larger and more legible.

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Examples.

(*a*) $2{\cdot}5 \times 3{\cdot}7 = 9{\cdot}25$.

Using the lower scale, slide out to the right.

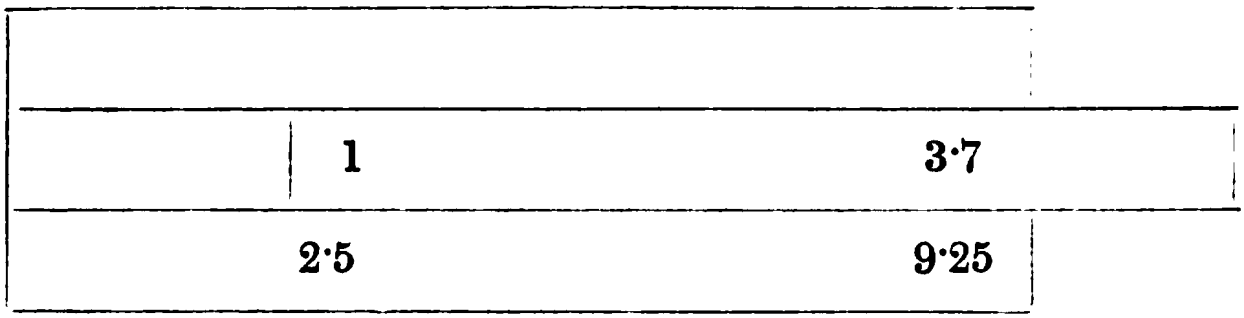

Fig. 13.

(*b*) $6{\cdot}7 \times 8{\cdot}5 = 56{\cdot}95$.

Using the lower scale, slide out to the left.

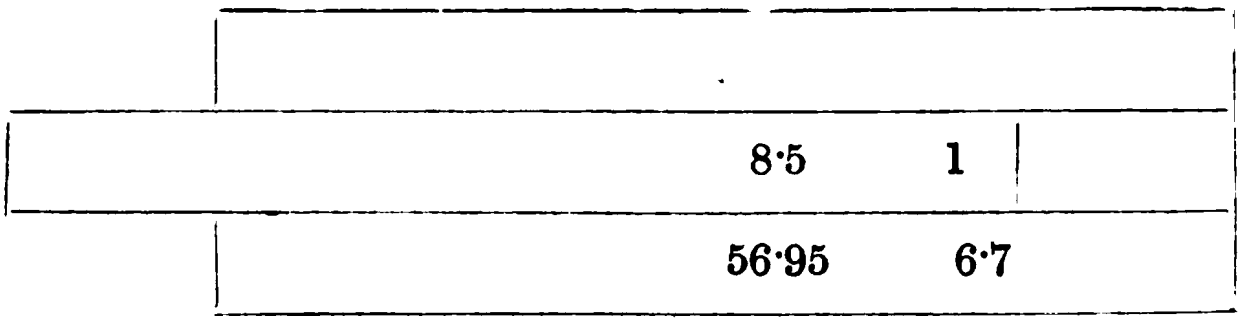

Fig. 14.

Common same will generally suffice to determine the position of the decimal point. The following rules, however, may be found useful.

When the slide is out to the right the number of integers in the product is one less than the number of integers in the factors.

When the slide is out to the left the number of integers in the product is equal to the number of integers in the factors.

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The last figure of the product may be obtained by mental arithmetic if it cannot be read otherwise.

3. *Division.*—Place divisor on slide opposite dividend on rule and opposite 1 on the slide will be found the quotient on the rule.

Either the two upper or the two lower scales may be used, but the latter have larger graduations and are therefore preferable.

Examples.

(a) 90·5÷25 = 3·62.

Using the lower scale, slide out to the right.

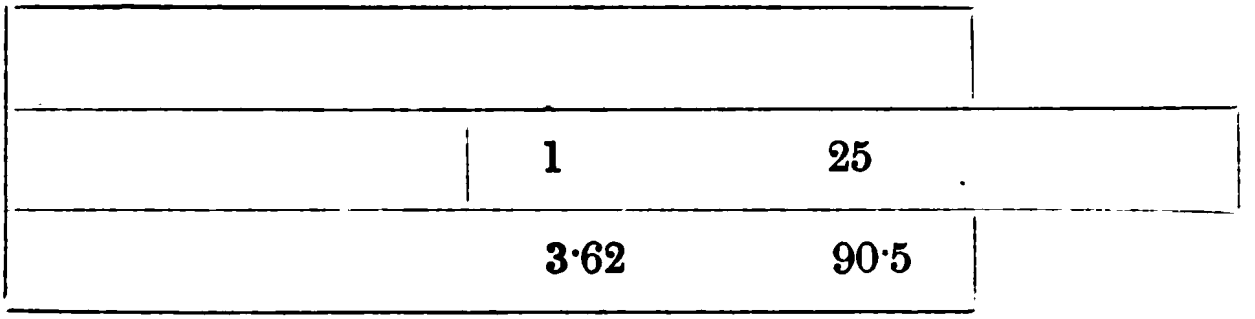

Fig. 15.

(b) 17·29÷2·6 = 6·65.

Using the lower scale, slide out to the left.

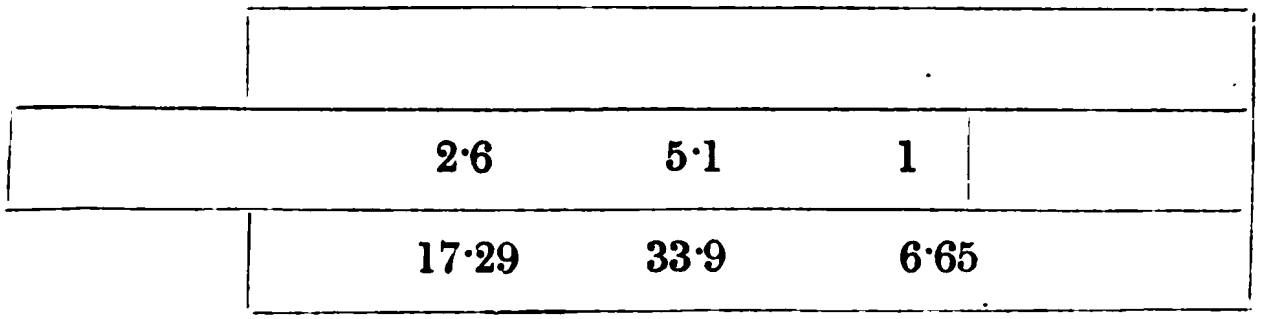

Fig 16.

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When the slide is out to the right the number of integers in the quotient is one more than the number of integers in the dividend less the number of integers in the divisor.

When the slide is out to the left the number of integers in the quotient is equal to the number of integers in the dividend less the number of integers in the divisor.

4. *To multiply by a fraction.*—This can always be done with the upper scales in one setting and sometimes with the lower scales.

Set the slide as if for division by the denominator. Opposite the numerator on the slide will be found the answer on the rule.

Example.

$$17{\cdot}29 \times \frac{5{\cdot}1}{2{\cdot}6} = 33{\cdot}9 \text{ (}see\text{ Fig. 16).}$$

5. *Proportion.*—A problem in simple proportion, such as

$$a : b :: c : x,$$

may be written in the form

$$a/b = c/x \quad \text{or} \quad b/a = x/c.$$

Set the rule so that the upper scale represents the above equation, thus.—

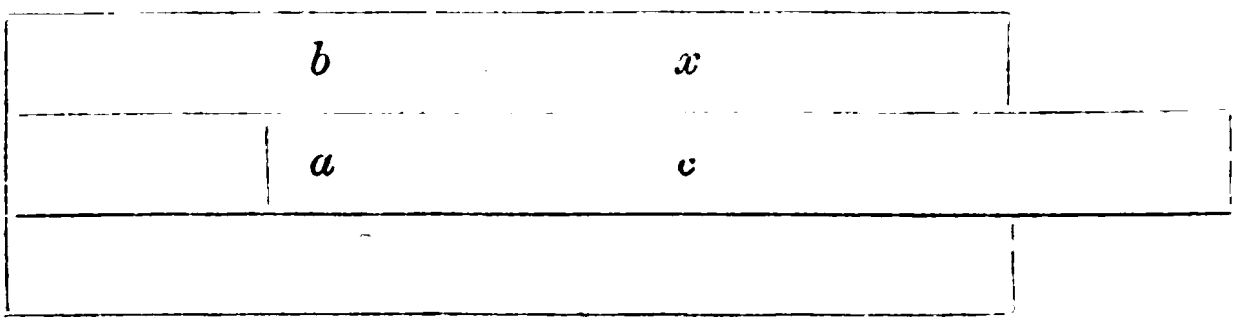

Fig. 17.

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Example.

$85 : 17 :: 145 : x.$

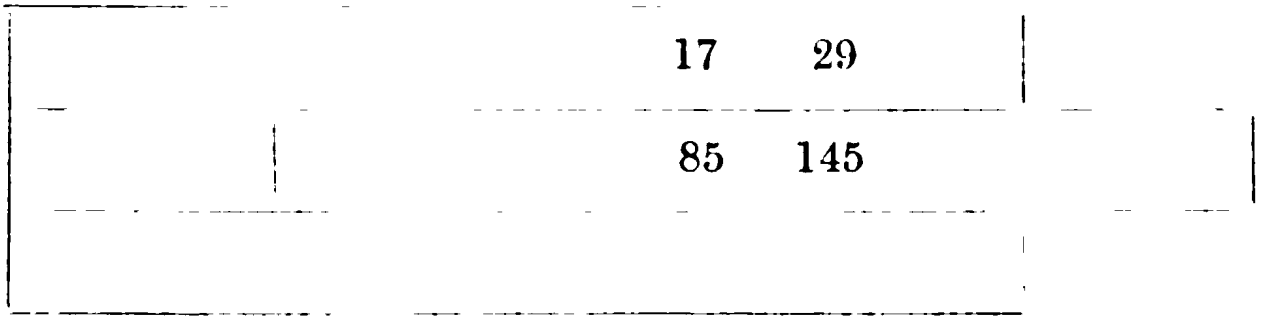

Fig. 18.

Here $x = 29$.

6. *To square a number.*—Read the number on the lower scale of the rule. Over it on the upper scale of the rule will be found its square.

Example.

Find the value of 19^2.

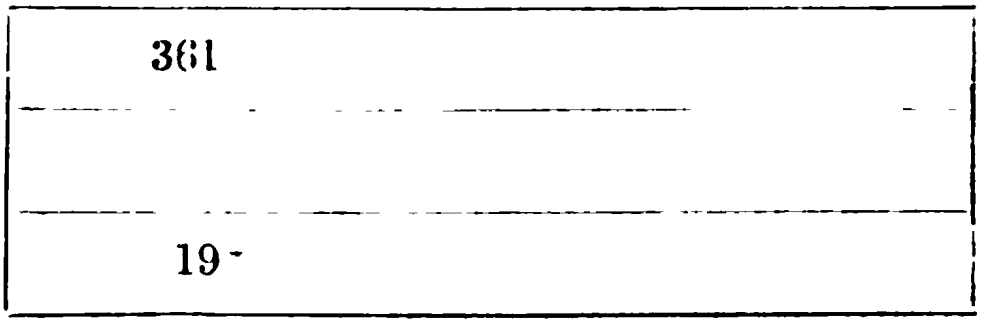

Fig. 19.

Answer. $19^2 = 361$

7. *To find the square root of a number.*—Read the number on the upper scale of the rule, using the left-hand upper scale if it has an uneven number of integers and the right-hand upper scale if it has an even number of integers. Its square root will be found below it on the lower scale of the rule.

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Example.

Find the values of $\sqrt{529}$ and $\sqrt{16{\cdot}8}$.

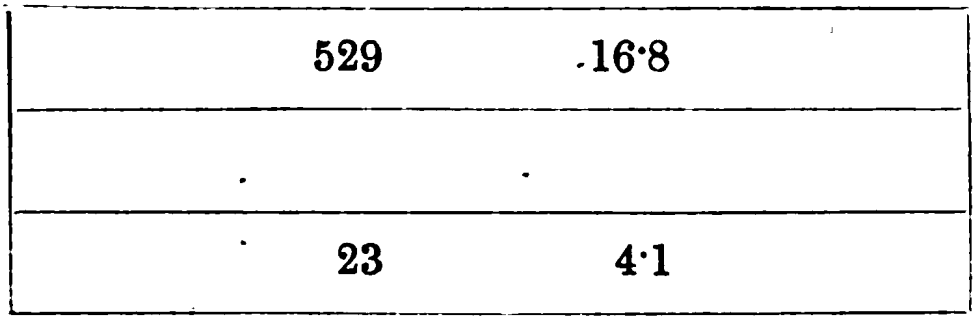

Fig. 20.

Answer. $\sqrt{529} = 23$; $\sqrt{16{\cdot}8} = 4{\cdot}1$.

8. *To convert angles into slopes.*—Upset the slide, *i.e.*, set it so that the S scale of the slide is in contact with the upper scale of the rule.

Use the S scale of the slide with the upper scale of the rule for angles up to 5° 44, and the T scale of the slide with the lower scale of the rule for angles greater than 5° 44′.

Place the angle on the slide opposite the left 1 on the rule and opposite the right end of the scale on the slide will be found the slope on the rule.

Examples.

(*a*) What is the slope corresponding to an angle of 2° 20′?

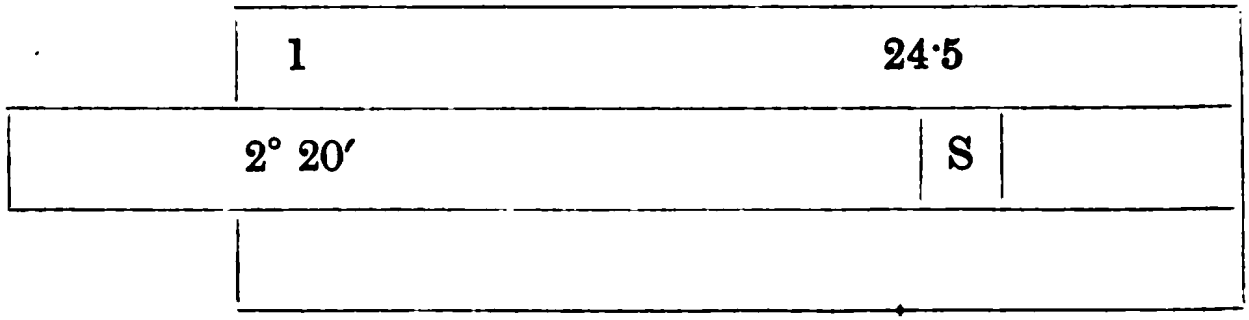

Fig. 21.

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Answer. 2° 20′ = a slope of 1 in 24·5.

(*b*) What is the slope corresponding to an angle of 6° 40′?

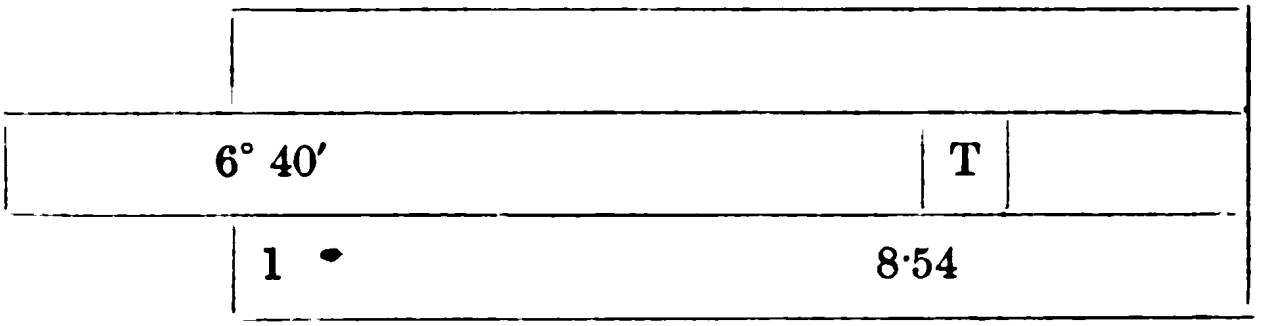

Fig. 22.

Answer. 6° 40′ = a slope of 1 in 8·54.

For angles under 35′ divide 3438 by the angle in minutes.

(*c*) What slope corresponds to an angle of 20′?

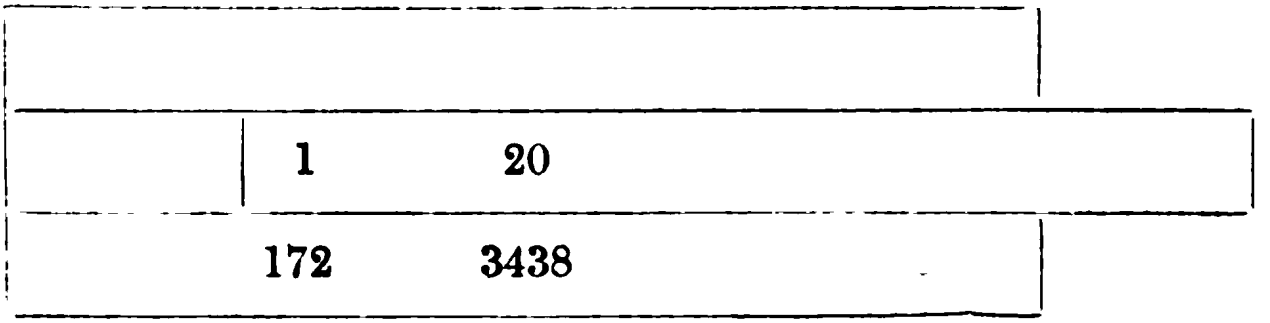

Fig. 23.

Answer. 20′ = a slope of 1 in 172.

This method may be used for all angles up to 6°.

9. *To convert slopes into angles.*—Reverse the methods just given. For slopes from 1 to 1/10 use the T scale. For slopes from 1/10 to 1/35 use the S scale.

For gentler slopes use the 3438 method.

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10. *To find the angles of sight for different ranges from a battery.*—Invert the slide, *i.e.*, turn it upside down. Place 1146 on what is now the lower scale of slide under the height of the battery in feet, on the upper scale of the rule. Over the ranges on the lower scale of the slide will be found the angles of sight in minutes on the upper scale of the rule.

Example.

Height of battery, 200 feet. What are the angles of sight for 3,000, 4,000, and 5,000 yards?

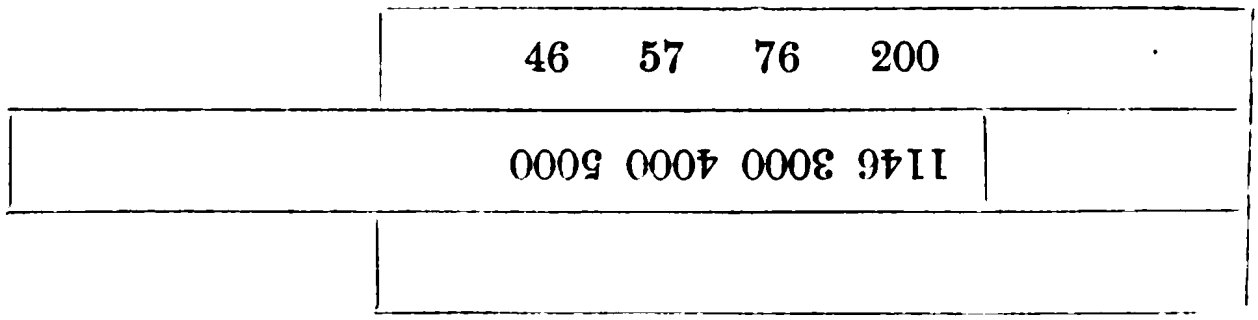

Fig. 24.

Answer. The angles of sight for 3,000, 4,000, and 5,000 yards are 76, 57, and 46 minutes respectively. But *see also* App. II, Sec. 1, para. 1.

11. *To find the dangerous space for a vertical target.*—Upset and invert the slide, *i.e.*, use the sine tangent scale upside down. Move the slide till the end of the scale comes opposite the height of the target in yards on one of the scales of the rule; then bring the cursor over the angle of arrival on the proper scale of the slide, and the value of the dangerous space in yards will be found under the cursor on the scale on which the height of the target was taken.

Note.—If the angle of arrival is less than 5° 44′, use the

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upper scale of the rule and the sine scale of the slide. If the angle of arrival is greater than 5° 44′, use the bottom scale of the rule and the tangent scale of the slide.

Example.

What is the dangerous space of a target 27 feet high when the angle of arrival is 8° ?

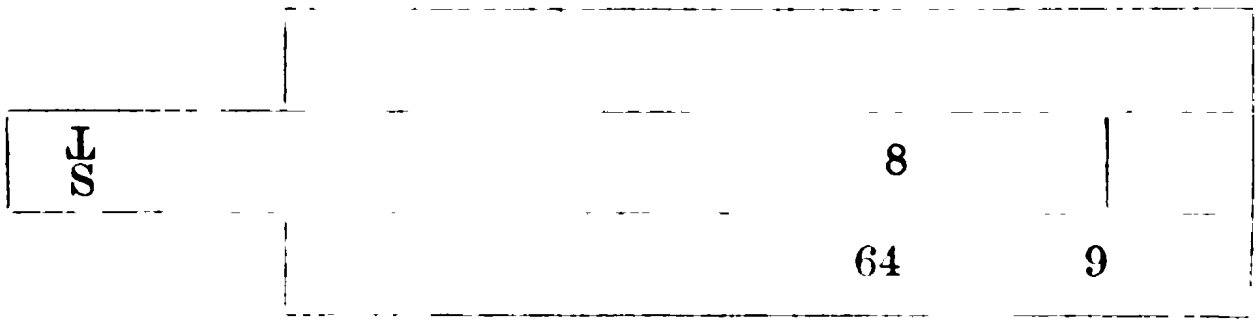

Fig. 25.

Answer. The dangerous space is 64 yards.

If the target has beam, the beam must be added to give the whole dangerous space.

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APPENDIX II.

GUNNERY PROBLEMS.

1. *Calculations of angles.*

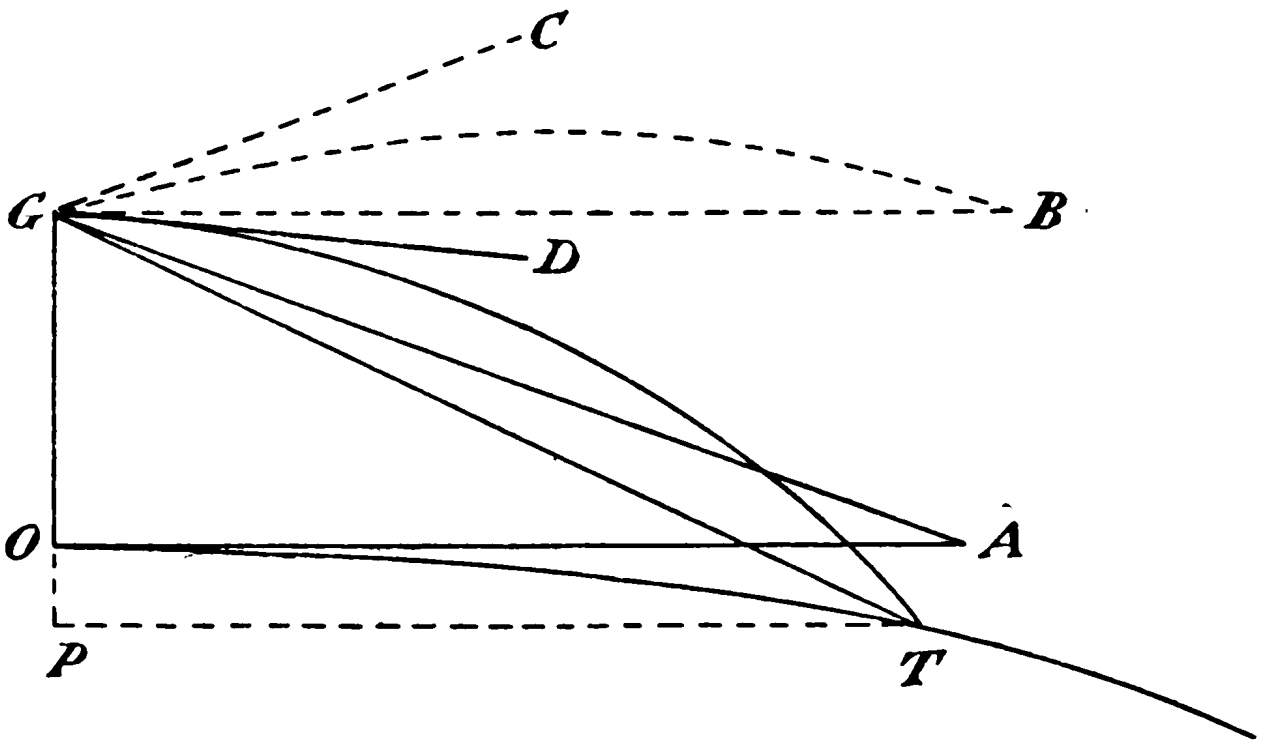

Fig. 26.

1. *To find the angle of sight.* (*See* p. 13.)—In Fig. 26 let G be the axis of the trunnions of a gun at height GO = h feet and let T be a target on the water at a range of R yards. Through G draw the horizontal line GB.

Then the angle of sight is BGT.

Through O draw the horizontal line OA, and with centre

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G and distance GT describe a circle cutting OA in A; then GA = GT = R and GAO = BGA, the angle of sight to the point A.

From the range-finding formula given in App. I, Sec. 2, if m be the number of minutes in the angle GAO,

$$m = \frac{h \times 1146}{R}.$$

To get the true angle of sight the angle AGT must be added, and it can be proved that the number of minutes in this angle is 0·246 per 1,000 yards of range.

In other words, if a be the angle of sight to T,

$$a = m + \frac{R}{1000} \times \cdot 246 \text{ minutes.}$$

Another method of arriving at the same result is to consider the curvature of the earth as adding to the height of the gun by an amount OP (TP being drawn parallel to AO to cut GO in P). It can be proved that OP = $\frac{2}{3}r^2$ feet when r is the range in miles. If we call OP h_1 feet, applying the range-finding formula to the triangle GTP, in which the angle GTP = BGT = the angle of sight to T,

$$a = \frac{(h + h_1) \times 1146}{R}.$$

The first method is generally the more convenient for use in simple gunnery problems, and, where extreme accuracy is not required, a may be taken as $= \frac{h \times 1146}{R}$.

2. *To find the quadrant angle.* (*See* p. 14.)—

Range table elevations are made out on the assumption that the gun and target are on the same horizontal plane.

When a gun, mounted in a coast battery above sea level,

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is laid with quadrant elevation, a correction must be made to the elevation given in the range table.

Suppose a gun at G (Fig. 26) firing at a target at B on the same horizontal plane required an angle of elevation CGB according to the range table.

Then to hit at T at the same range as B but on the sea level an angle of elevation of DGT, equal to CGB, would be required.

Now DGB is equal to DGT—BGT, where DGB is the quadrant angle, DGT the range table (or tangent) elevation and BGT the angle of sight.

Therefore the quadrant angle is equal to the tangent elevation – the angle of sight.

The quadrant angle will be one of elevation or depression, according as the tangent elevation is greater or less than the angle of sight.

3. *Correction of elevation for high sited batteries.*—i. In the case of very high sited batteries there is a sensible gain in range due to the inclined line of sight, especially at long ranges.

Let G be a gun firing at a range GT = R, and let TGA be the angle of projection.

From T draw TA at right angles to TG.

Then in the case where GT is horizontal the shot will range to T and the trajectory may be resolved into two components, viz., GA along the line of departure and AT due to gravity.

Now if GT be inclined at an angle α, from A draw AP vertically downwards to meet GT produced to P.

Then the angle PAT = α, and when α is small AP = AT nearly, so that AP represents the gravity component of the trajectory.

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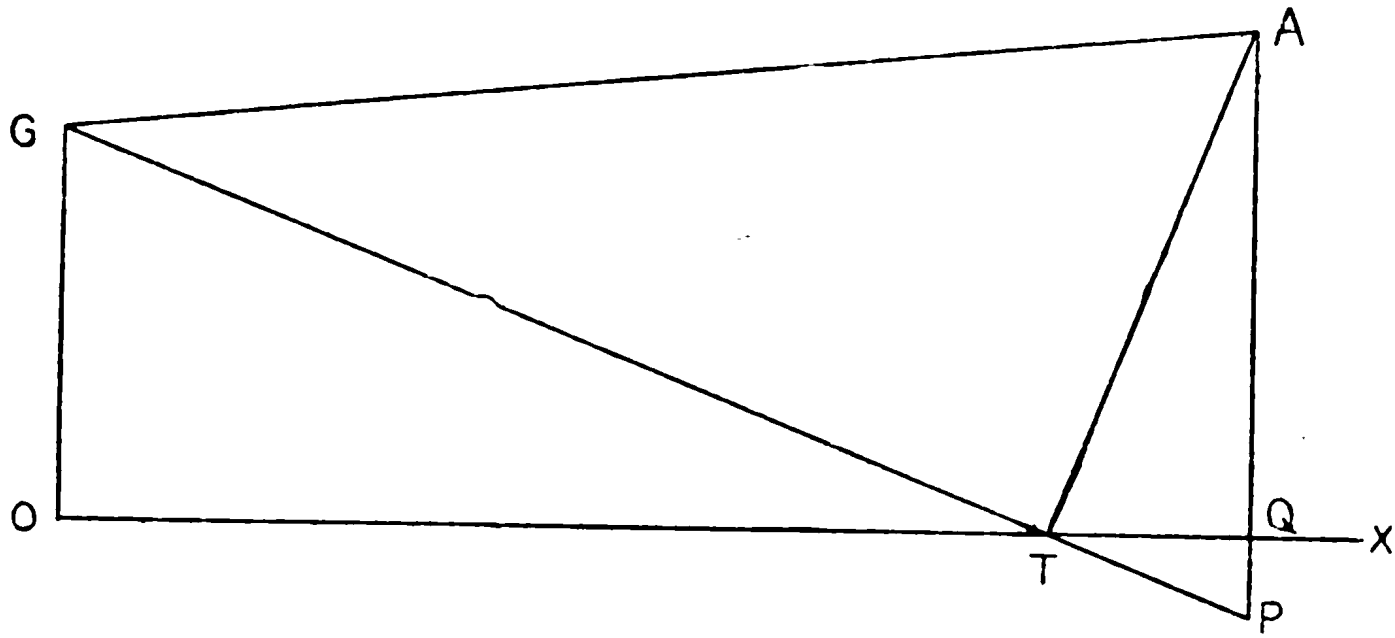

Fig. 27.

There is therefore a gain of range, measured along the line of sight, equal to PT.

$$PT = TA \tan \alpha$$
$$\text{and } AT = TG \tan \phi = R \tan \phi.$$
$$\therefore\ PT = R \tan \phi \tan \alpha.$$

ii. The correction in minutes of elevation can be obtained from the column in the range table headed "Variation in range corresponding to 5 minutes alteration of elevation."

iii. The automatic sight is designed to compensate for the gain in range by raising the line of sight and point of impact through the same angle to the point Q, so that auto-sighting conditions are still complied with without altering the angle of projection.

4. *To determine the angle of depression of a sight or telescope.*—The refraction, or bending of rays of light by the earth's atmosphere, has generally the effect of making an

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object appear higher than it really is. Therefore to direct a sight or telescope on to a target it must be laid at a less angle of depression than the true angle of sight. The average correction required for normal atmospheric conditions is ·035 minute per 1,000 yards of range. In other words, if d be the depression angle

$$d = a - \frac{R}{1000} \times \cdot 035 \text{ minutes} = m - \frac{R}{1000} \times \cdot 211 \text{ minutes.}$$

The correction for refraction may be also considered as reducing the extra height added by curvature by $\frac{2}{21} r^2$ when r is the range in miles (*see* para. 1).

Therefore the combined curvature and refraction corrections may be taken as adding a height of $\left(\frac{2}{3} - \frac{2}{\cdot 21}\right) r^2 = \frac{4}{7} r^2$ feet, or $\cdot 1845 \left(\frac{R}{1000}\right)^2$ feet when R is the range in yards.

This last formula gives the height correction which is used when levelling range-finding instruments.

For instance, the correction at 10,000 yards

$$= \cdot 1845 \times \left(\frac{10000}{1000}\right)^2 = 18 \cdot 45 \text{ feet.}$$

NOTE.—In the case of gun sights the height of the telescope must be taken for h in the range-finding formula, trunnion heights of guns being corrected according to the following data :—

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Automatic sight telescopes.—

12-pr. Q.F....	...	13 inches	above	gun axis.
4′ Q.F. ...	...	16 „	„	„
4·7″ Q.F. ...	...	12 „	„	„
6″ B.L. VII.	...	22 „	„	„
9·2″ B.L. X.	...	24 „	„	„
6-pr. sub-cal.	...	13 „	below	„

5. *Calculations in connection with datuming auto-sights* (*see* Sec. **141**)—

(*a*) *To calculate the depression angle for a given range*—

Example : Height of telescope above M.S.L., 41·83 feet.
Range of datum, 1,500 yards.

Then $m = \frac{41{\cdot}83 \times 1146}{1500} = 31{\cdot}958$ minutes.

Correction for curvature and refraction $= \frac{{\cdot}211 \times 1500}{1000} =$ ·3165 minute.

∴ the angle to be placed on the sight is

$$31{\cdot}958 + {\cdot}3165 = 32{\cdot}27 \text{ minutes.}$$

(*b*) *To calculate the corresponding range when a natural mark is taken as a false datum*—

Test the telescope for collimation and parallax. Lay on the false datum and measure the depression angle with a reliable clinometer, repeating the process several times in order to obtain a reliable mean reading.

Example : Height of telescope above M.S.L., 41·83 feet.
Depression angle to false datum, 33·25 minutes.

Then the corresponding range is approximately

$$\frac{41{\cdot}83 \times 1146}{33{\cdot}25} = 1442 \text{ yards.}$$

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Correction for curvature and refraction at this range is

$$\frac{\cdot 211 \times 1442}{1000} = \cdot 304 \text{ minute.}$$

$\therefore$ the range is $\frac{41\cdot 83 \times 1146}{33\cdot 25 - \cdot 304} = 1455$ yards.

6. *To find the angle of arrival.* (*See* p. 15.)—

Since the angle of arrival is measured with reference to the horizontal plane at the target, and this plane is a tangent to the curved surface of the earth, it is theoretically necessary to determine the angle which the line of sight makes with the tangent to the earth at the target and add it to the angle of descent.

It can be proved, using the same terms as in para. 1, that the first angle is $m - \frac{R}{1000} \times \cdot 246$ minutes.

Practically, however, it is sufficiently accurate to say that the angle of arrival is equal to the sum of the angle of descent and the angle of sight,

$$= \alpha + \beta$$

$$\text{taking } \alpha = \frac{h \times 1146}{R}.$$

Thus in Fig. 28 where GTX is approximately the angle of sight, and STG the angle of descent, STX is the angle of arrival.

2. *Correction of range tables for guns above the sea level.*

1. Several of the items in range tables have to be corrected in the case of batteries not at sea level.

2. To contain the corrected information, "Duplicate Range

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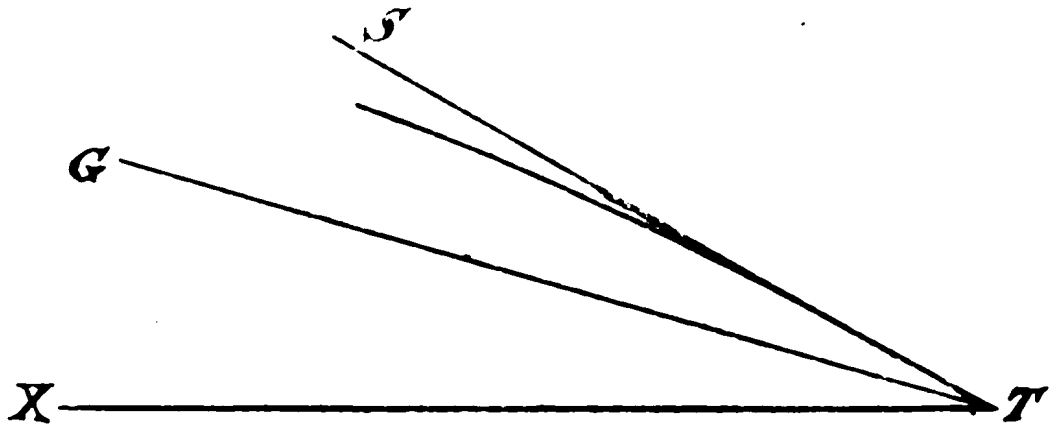

Fig. 28.

Tables" are issued, in which the columns which require alteration are left blank, whilst certain others are re-named, or added, so that each work may be provided with data suitable to itself.

Columns for the angle of arrival, quadrant elevation, and $\frac{\sin \beta}{\sin (\beta+a)}$ expressed as a decimal are inserted, whilst the columns dealing with variations of range due to various causes, as also that for the 50 per cent. length zone, are left blank.

The angle of arrival and the quadrant elevation are found as in App. II, Sec. 1.

3. The 50 per cent. length zone, and columns headed "Variation of range," are all affected by height in the following way.

Suppose a gun at G (Fig. 29), at a height GO above sea level, firing at a target T, and that the line of sight GT be produced to P, so that TP is equal to the 50 per cent. length zone of the gun, or to the variation in range produced by either 10 minutes alteration of tangent elevation, or 10 f.s. alteration of M.V., or 10 per cent. alteration of the ballistic

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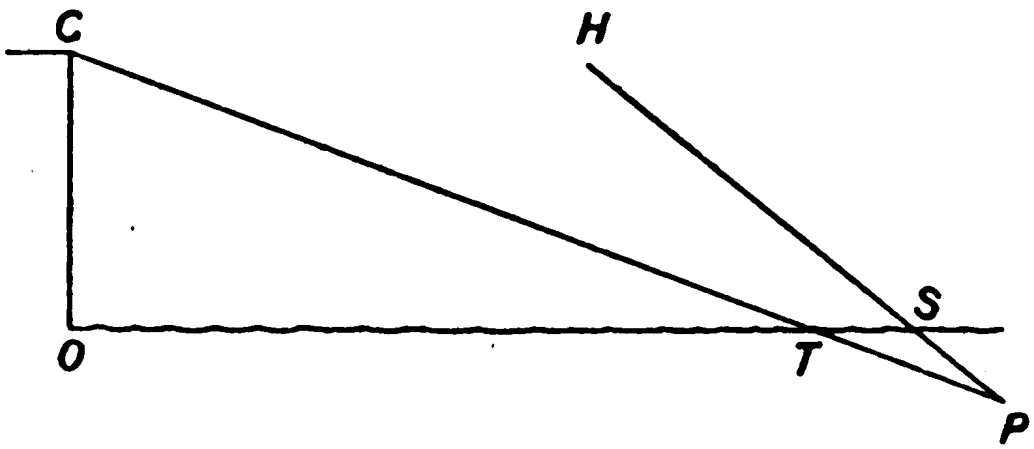

Fig. 29.

coefficient C, then TS is equivalent on the water to TP on the line of sight, where HSP is the tangent to the trajectory of a shot which would have ranged to P, cutting the water at S.

Now the sides of a triangle are proportional to the sines of the opposite angles, therefore

$$\frac{ST}{TP} = \frac{\sin TPS}{\sin PST} = \frac{\sin TPS}{\sin HST} = \frac{\sin \beta}{\sin (\beta + \alpha)}$$

where β is the angle of descent, α the angle of sight, and consequently $(\beta + \alpha)$ the angle of arrival.

$$\therefore \quad ST = \frac{TP \sin \beta}{\sin (\beta + \alpha)},$$

and this formula is easily used with a slide rule; but, when angles are small, their sines are proportional to them, so

$$ST = TP \frac{\text{minutes in angle of descent}}{\text{minutes in angle of arrival}},$$

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which is the most convenient formula, for small angles, when a slide rule is not available.

Example.—With 6-inch B.L. Mark VII gun at height 100 feet, and range 3,000 yards, the angle of sight as found App. II, 1, i, is 38′, the angle of descent is 2° 17′, the angle of arrival therefore is 2° 55′ and the corrected 50 per cent. length zone is

$$24 \times \frac{\sin 2^\circ\ 17'}{\sin 2^\circ\ 55'} = 18{\cdot}8 \text{ yards.}$$

The second formula, with such small angles, gives the same result.

The 50 per cent. breadth zone and 50 per cent. height zone are not affected by the height of the work.

The 50 per cent. height zone may be obtained directly from the corrected length zone by multiplying the latter by the tangent of the angle of arrival, but, for all practical purposes, the correction is negligible.

3. *Gun or group differences.* (*See* p. 17.)

1. With D.R.F. the range is found from the pillar of the instrument, with P.F. the range is found from the pivot gun. Therefore the range found will need correction, in the first case for all the guns in the battery, in the second case for guns other than the pivot gun.

The amount of correction, which is known as group (or gun) difference, depends on the displacement, or distance of the gun from the range-finder by which it is fought or from the pivot gun, and varies according to the training of the target. If the whole arc of the circle be considered, there are two trainings at which the difference is ±0 and two at which the difference is equal to the displacement, in the one case + and in the other —.

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2. It must be determined locally whether a group difference table will be required for each gun, or whether one table for the group will give sufficiently accurate results. In the latter case it will be worked out for the centre of the group.

3. It is generally advisable to work out a difference table for each gun, recording the corrections in multiples of 25 yards, a difference of less than $12\frac{1}{2}$ being ignored, differences between $12\frac{1}{2}$ and $37\frac{1}{2}$ being taken as 25, and so on. If then the training is ascertained at which the difference is $12\frac{1}{2}$ and the training at which it is at $37\frac{1}{2}$, at all trainings between them a correction of 25 yards is suitable, and so on for the rest of the circle.

4. In Figs. 30 and 31 let R be the range-finder and G the gun, so that the displacement is RG. When the gun is laid on R or in the line RG produced to H the difference is equal to the displacement.

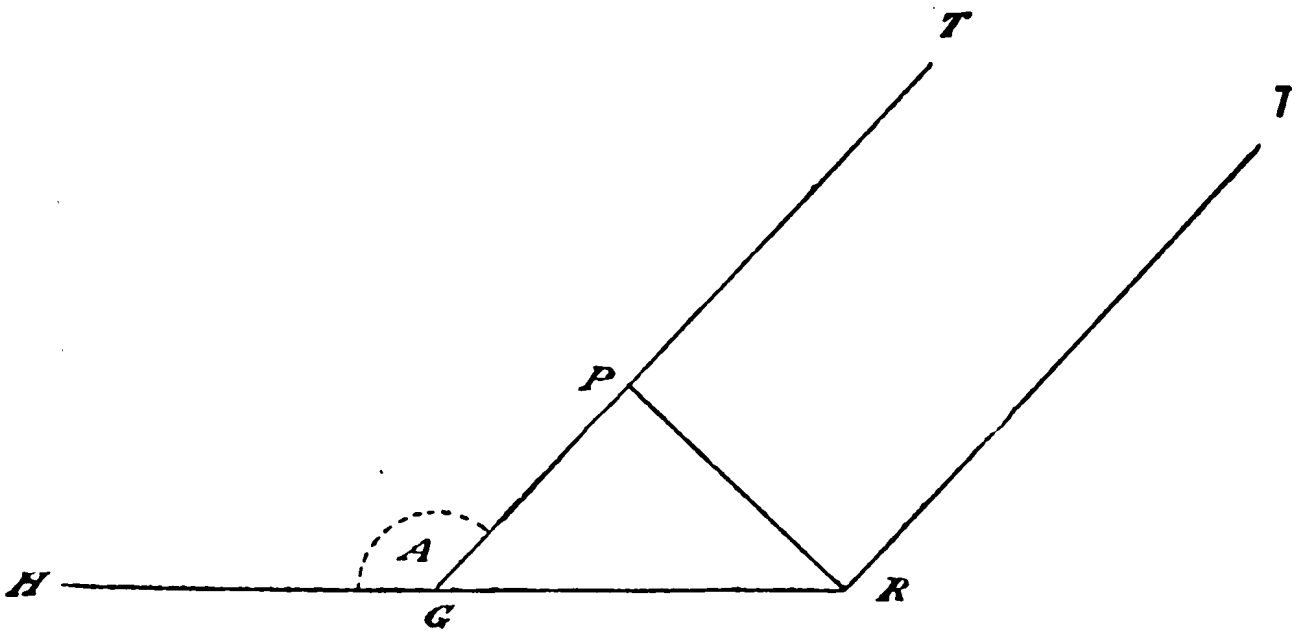

Fig. 30.

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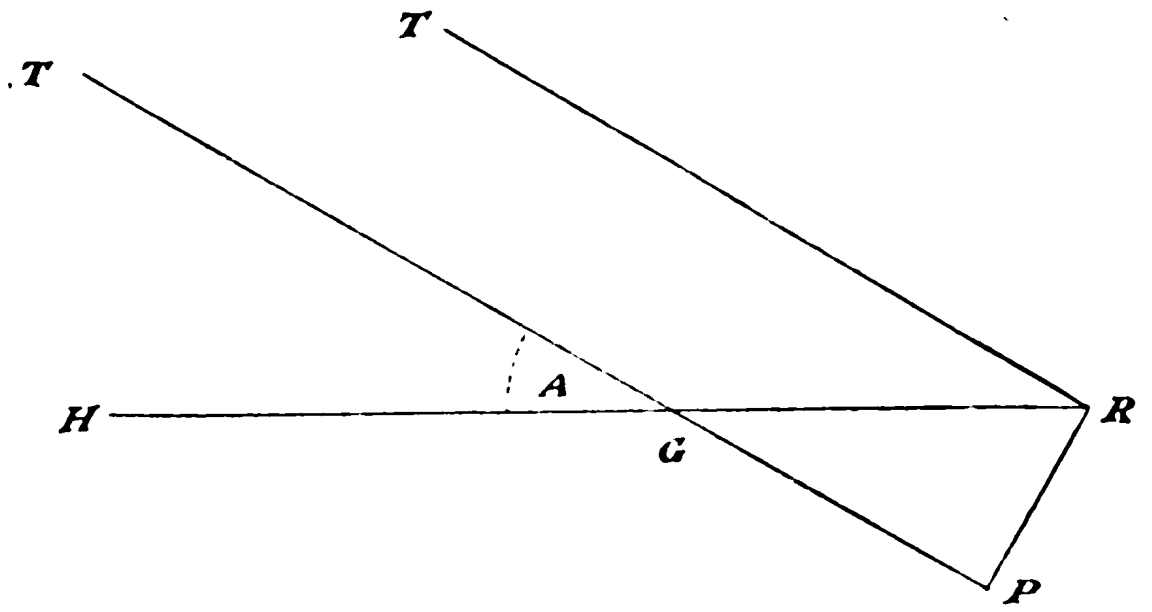

Fig. 31.

Let the gun be traversed through an angle HGT so that it is laid on a target at T. Draw RP perpendicular to TG or TG produced.

Now the distance to T is so great compared to RP that RT and PT may be considered equal ; therefore the difference required is PG.

(In Fig. 30 the difference is + and in fig. 31 it is —.)

$$PG = GR \cos PGR = GR \cos HGT,$$

or $d = D \cos A$ where d is the difference, D is the displacement, and A is the angle through which the gun has been traversed from the line joining range-finder to gun.

To find the angle at which the difference is a certain definite amount we have

$$\cos A = \frac{d}{D}.$$

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Since $\cos A = \sin (90° - A)$ we can determine A rapidly by means of the slide rule, using the formula for solution of a triangle

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}.$$

For example, if D = 72 yards, set the slide rule with sin 90 under 72, thus :—

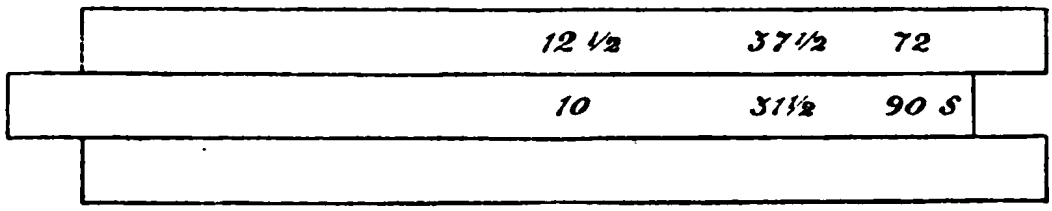

Fig. 32.

Under $12\frac{1}{2}$, $37\frac{1}{2}$, and $62\frac{1}{2}$, will be found the sines of the angles 10°, $31\frac{1}{2}$°, and 60° respectively, therefore $(90-10)$, $(90-31\frac{1}{2})$ and $(90-60)$, or 80°, $58\frac{1}{2}$° and 30°, are the angles at which differences of $12\frac{1}{2}$, $37\frac{1}{2}$, and $62\frac{1}{2}$ yards respectively would be correct.

So in this case up to 30° from the line joining range-finder to gun the difference will be taken as −75, from 30° to $58\frac{1}{2}$° as −50, from $58\frac{1}{2}$° to 80° as −25, and from 80° to 90° as ±0.

When the perpendicular from R falls between gun and target, as in Fig. 30, the angle A must be subtracted from 180°. To continue the example: the differences will be taken as ± 0 from 90° to 100°, as +25 from 100° to $121\frac{1}{2}$°, as +50 from $121\frac{1}{2}$° to 150°, and as +75 for the remainder.

5. To ascertain the training RG, set up and orient the D.R.F., lay it on the gun and read the training on the graduated plate. An alternative method is to align the axis of the gun backwards on the D.R.F. and read the training on the traversing arc. It is often advisable to do both as a check

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on the orientation of gun and range-finder, and when different readings are obtained, the reading on the traversing arc must be taken as correct. When determining differences for a gun from a pivot gun the second method must be employed, laying one gun on the other.

If the gun is not provided with a traversing arc it will be laid backwards on the D.R.F., thus obtaining a zero line from which the angles determined can be set out.

6. A table can now be made out giving the trainings between which particular differences are suitable, only noting those that come into the arc of fire of the gun.

To continue the above example—

Suppose the training RG to be 107°, and that the arc of fire of the gun is from 320° to 120°, the table should be made out thus :—

DIFFERENCE TABLE.

B 2.

D.R.F. 72 yards to right rear.

Training.		Add.	Subtract.
320	to 345½	50	
345½	7	25	
7	27	0	0
27	48½		25
48½	77		50
77	120		75

7. In certain works it may be considered advisable to apply corrections which are multiples of 50 yards. In such cases differences of less than 25 are ignored, differences between 25 and 75 are taken as 50, and so on.

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8. When corrections for tilted pivot are necessary (*see* Sec. 5) it is convenient to plot the differences by a curve from which a second curve may be obtained giving the net correction for difference and tilt (*see* Plate II).

ab is the group difference curve and *gh* is the combined curve for group difference and tilted pivot. The combined table would be made out thus :—

NET CORRECTION FOR GROUP DIFFERENCE AND TILT.

B. 2.

D.R.F. 72 yards to right rear.

Elevation indicator to read correct at Training 40.

Training.	Add.	Subtract.
320 to 330	50	
330 350	25	
350 15	0	0
15 99		25
99 120	0	0

4. *Effect of tilted pivot.*

The roller path or ball race of a mounting should be truly horizontal and the pivot should be vertical. After a mounting is erected slight subsidence may occur, with the result that the mounting, when traversed, revolves around an axis which is inclined at a certain angle to the vertical. The effect on the gun will be greatest when it is laid in the direction to or from which the axis is inclined, and the effect in other directions may be found as follows :—

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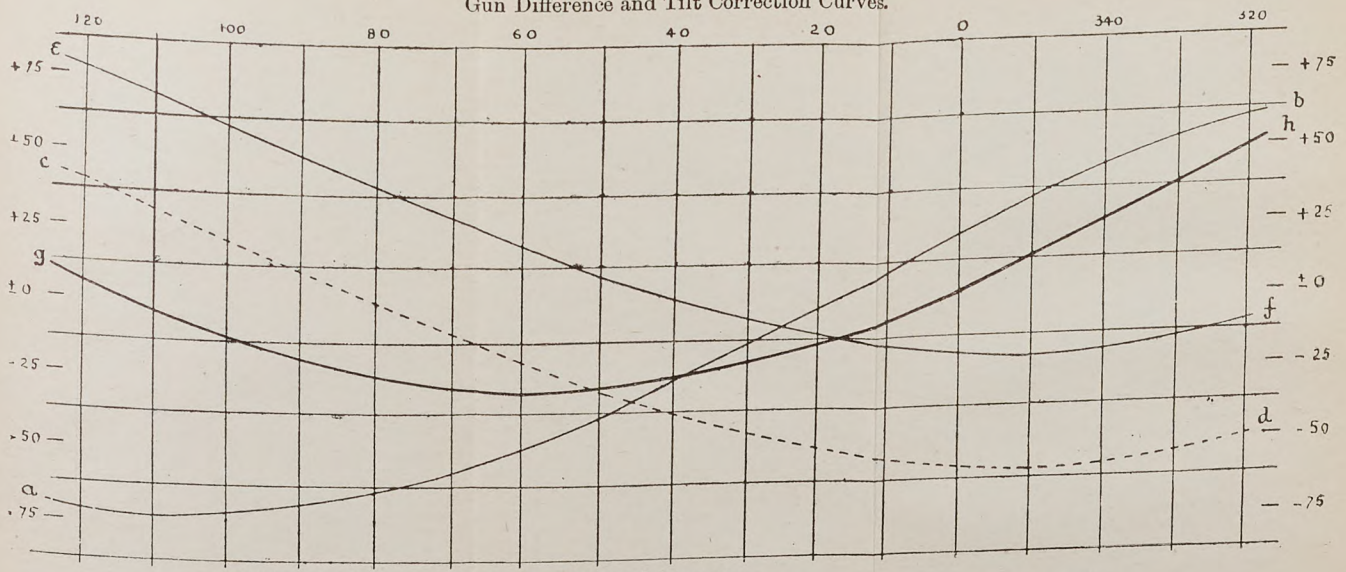
(*To face p.* 216.)

PLATE II.

B 2.

Gun Difference and Tilt Correction Curves.



ab. Gun differences ; D.R.F., 72 yards to right rear.
cd. Correction for tilt at 9,000 yards if elevation indicator is adjusted at position of no tilt.
ef. " " " " training 40.
(N.B.—Maximum tilt = 4 mins. at training 350.)
gh. Correction for gun differences and tilt = combination of *ab* and *ef.*

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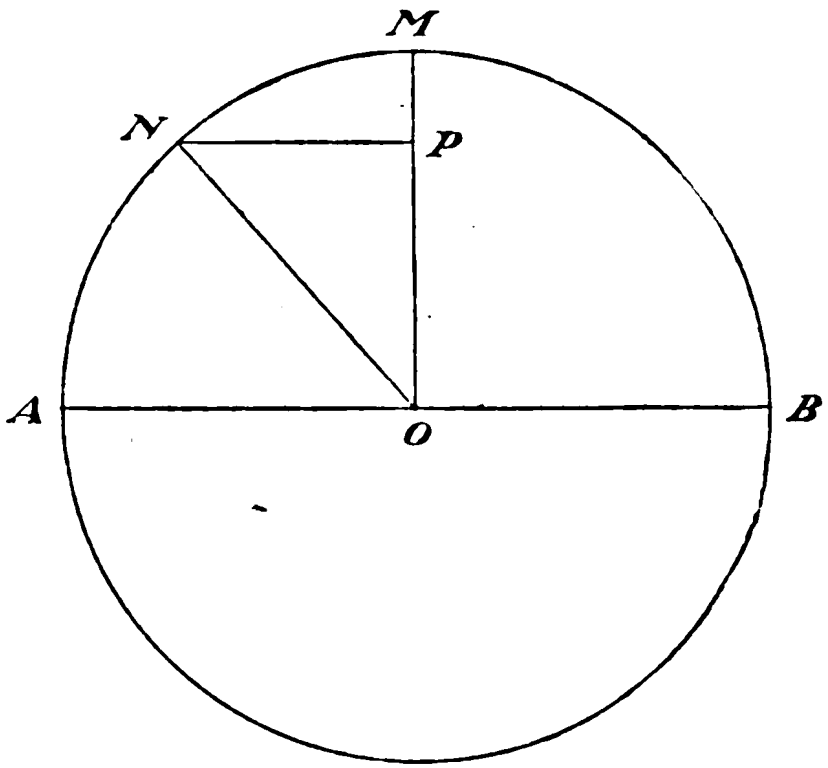

Fig. 33.

Let the circle in Fig. 33 represent a roller path which is tilted so that the maximum effect on the mounting is m minutes in the direction OM. Let the tilt in another direction ON be n minutes. From N draw NP perpendicular to OM. Then the points N and P are both the same height above a horizontal plane passing through O. Call this height p.

Then $$\sin n = \frac{p}{NO} \quad \text{and} \quad \sin m = \frac{p}{PO},$$

$$\therefore \quad \frac{\sin n}{\sin m} = \frac{PO}{ON} = \cos NOP,$$

$\therefore$ since n and m are small angles,

$$n = m \cos NOP.$$

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Thus the effect at any training is equal to the maximum tilt multiplied by the cosine of the angle through which the gun has been traversed from the direction of maximum tilt. It is obvious that the effect along the diameter AB, at right angles to OM, is nil ; the result given by the formula is also $m \cos 90° = 0$.

5. *Correction for tilt when laying by elevation indicator.*

1. To determine the corrections necessary at trainings other than that for which the elevation indicator was adjusted (*see* Sec. **143**), keep the elevation indicator set to the test range and traverse the mounting, halting every thirty degrees. Measure the Q.E. of the gun at each training and note the difference in each case between the Q.E. and that for which the elevation indicator was adjusted.

The alteration in range due to a variation of 5 minutes in Q.E. is tabulated for every range in the corrected range table ; the proper range correction at each training can be deduced therefrom and plotted as a curve (*see ef* in Plate II). The trainings between which corrections of + 25, ±0 −25, &c., are suitable can be read off and tabulated thus :—

CORRECTION FOR TILT, CASE II AND III.

B 2.

Elevation indicator to be adjusted at Training 40.

Training.	Add.	Subtract.
320 to 326	0	0
326 21		25
21 52	0	0
52 78	25	
78 103	50	
103 120	75	

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2. In the event of group differences being also necessary, the two corrections can be blended into one curve and tabulated (*see* Sec. 3).

3. Care must be taken in carrying out the above test not to be misled by irregular readings of clinometer due to faults in rollers. Errors due to this cause cannot be corrected.

4. Correction for tilt is a complication which can be avoided by levelling the mountings of 6-inch guns and under.

6. *Drift.* (*See* p. 14.)

When giving direction by traversing arc it is necessary to correct for drift.

The correction for drift is found by multiplying the number of degrees in the permanent angle at which the sight is inclined to the vertical (given in the handbook of the gun) by the number of degrees in the tangent elevation for the range. The result is the number of minutes left deflection required to correct for drift. The effect of this correction is always to increase the training.

(With 9·2-inch guns on Mark V mountings the inclination of the sight overcorrects for drift, this is compensated for at long and medium ranges by marking the zero of the deflection scale 6½ minutes to the right of the true zero. If 6½ minutes be deducted from the number of minutes for any elevation found by the above rule, the true deflection for drift will be obtained at long and medium ranges.)

The proper drift corrections should be made out for every 1,000 yards of range and entered on a table or diagram.

Drift, expressed in lateral units, varies very closely as the square of the time of flight.

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7. *Convergence.*

1. When guns are laid for direction by traversing arc, and the same training is given to each, their lines of fire will be parallel. In order to converge their fire, a "convergence correction" must be made, except for the pivot gun.

2. The amount of convergence required can be found from a table.

As arcs can only be read to $\frac{1}{8}°$, a convergence correction between 3·75′ and 11·25′ is taken as $\frac{1}{8}°$, between 11·25′ and 18·75′ as $\frac{1}{4}°$, and so on.

3. *A convergence table is prepared as follows* :—

The distances in feet between the line of fire of a gun and that of the pivot gun are measured at an extreme and at a central training, and their mean is taken as the average distance between lines of fire.

Find the ranges at which the corrections would be $\frac{1}{16}°$, $\frac{3}{16}°$, $\frac{5}{16}°$, &c., by multiplying the average distance between lines of fire by 1146 and dividing by 3·75, 11·25, 18·75, &c., thus obtaining the zones over which $\frac{1}{8}°$, $\frac{1}{4}°$, $\frac{3}{8}°$, &c., are suitable corrections.

A table should then be made out in the following form, and an extract for each gun should be made out on a card, for the use of the setter.

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_____ Battery.

A. Group, 3 guns, pivot gun A 2.
Gun pivots 100 feet apart.
Average distance between lines of fire, 75 feet.

Ranges.	Angle of Convergence. Degrees.	
	A 3, deduct, or more Right.	A 1, add, or more Left.
Over 7600	$\frac{1}{8}$	$\frac{1}{8}$
7600		
	$\frac{1}{4}$	$\frac{1}{4}$
4600		
	$\frac{3}{8}$	$\frac{3}{8}$
3300		
	$\frac{1}{2}$	$\frac{1}{2}$
2500		
	$\frac{5}{8}$	$\frac{5}{8}$
2100		
	$\frac{3}{4}$	$\frac{3}{4}$
1750		
	$\frac{7}{8}$	$\frac{7}{8}$
1500		
	1°	1°
1353		

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8. *To raise or lower the point of impact when laying by elevation indicator*

1. Elevation indicators are graduated for height of the gun above mean sea level. When the gun is laid for a given range, the trajectory will therefore pass through a point at that range at mean sea level.

2. At other states of the tide, errors in shooting will result unless the elevation of the gun is corrected by giving more or less range (more for rise, less for fall), thus making the trajectory pass through a higher or lower point at the same range as before.

3. Also, whatever the state of the tide, it will generally be required to raise the point of impact to hit some point on the target above the water line.

4. The correction necessary for either of the above conditions may be determined as follows :—

Let G be the gun at height GO above mean sea level OX, and let P be the point to which a shot will range when the gun is laid with no correction. (*See* Figs. 34 and 35.)

Let GSQ or GQS be the new trajectory, to hit the point S at the same range as the point P, intersecting OX in Q.

Then PQ is the range correction required, measured along the water at mean sea level.

Assume that the angle of arrival for the range GQ is the same as for the range GP, and that the portion of the trajectory between S and Q is practically a straight line, then $\frac{SP}{PQ} = \tan(\beta+\alpha)$, $\therefore PQ = \frac{SP}{\tan(\beta+\alpha)}$.

5. The correction necessary to raise or lower the point of impact 10 feet (*i.e.*, when SP = $3\frac{1}{3}$ yards) should be tabulated for every thousand yards of range or drawn as a curve.

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The correction necessary for other heights can then be determined by simple arithmetic.

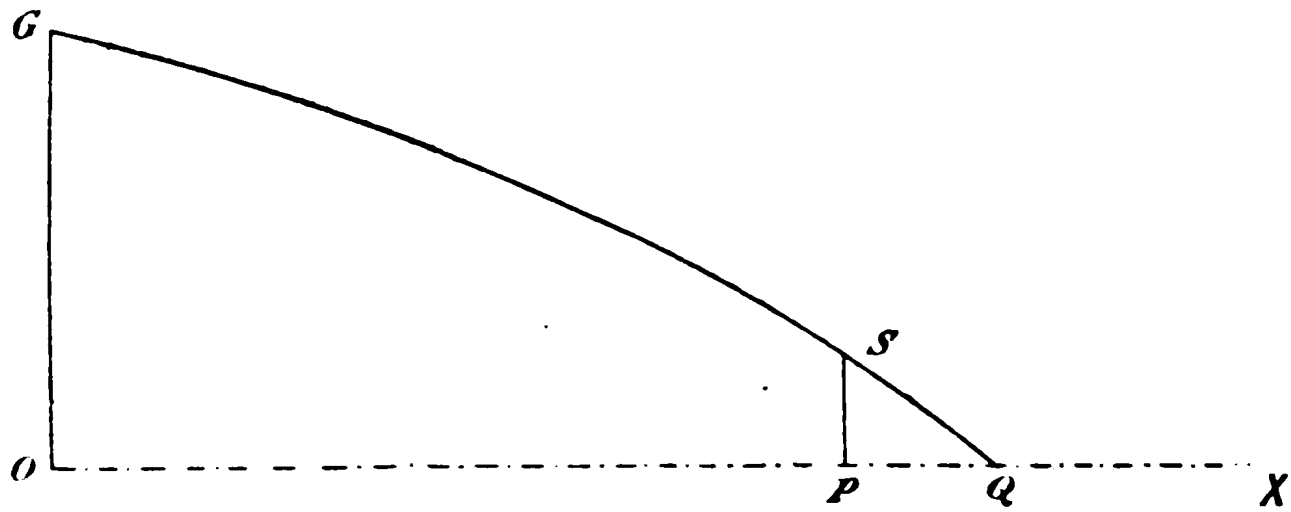

Fig. 34.

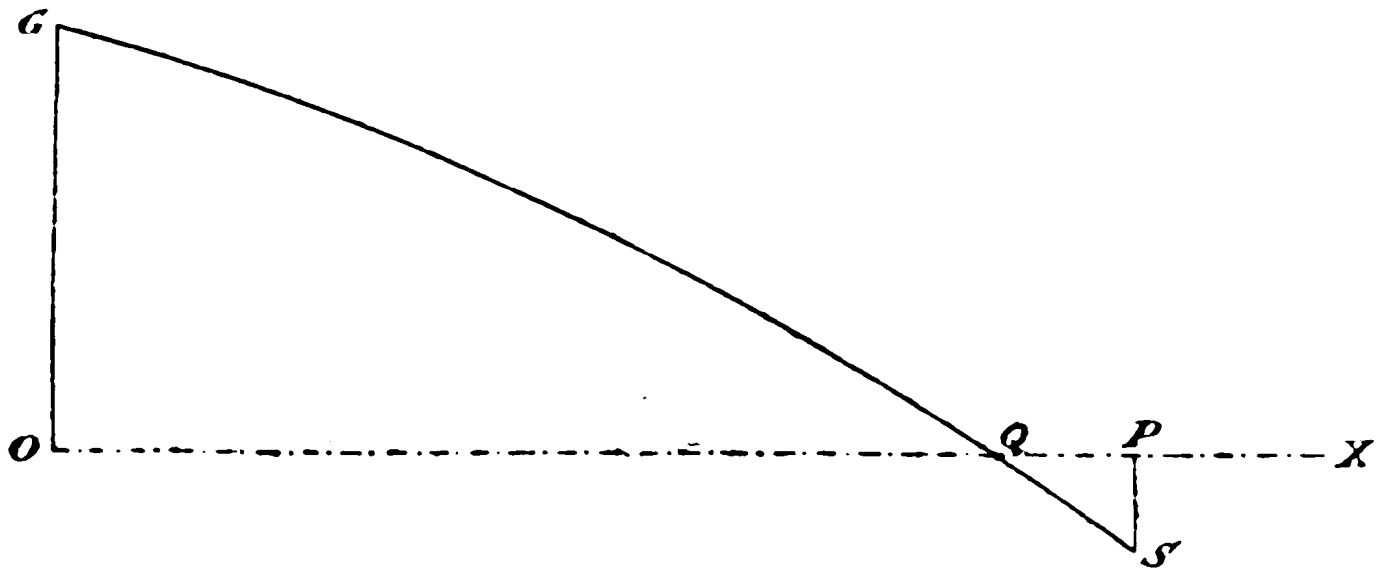

Fig. 35.

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9. *To determine the dead water for a gun.*

Let G be a gun at height GO above M.S.L. OX (*see* Fig. 36), and let C be a point on the summit of a ridge of land intervening between the gun and part of the water area of the fortress. Ascertain the range GC and the angle of sight BGC (the range GC and the difference in height between G and C can often be conveniently found from a map), to this add CGD,

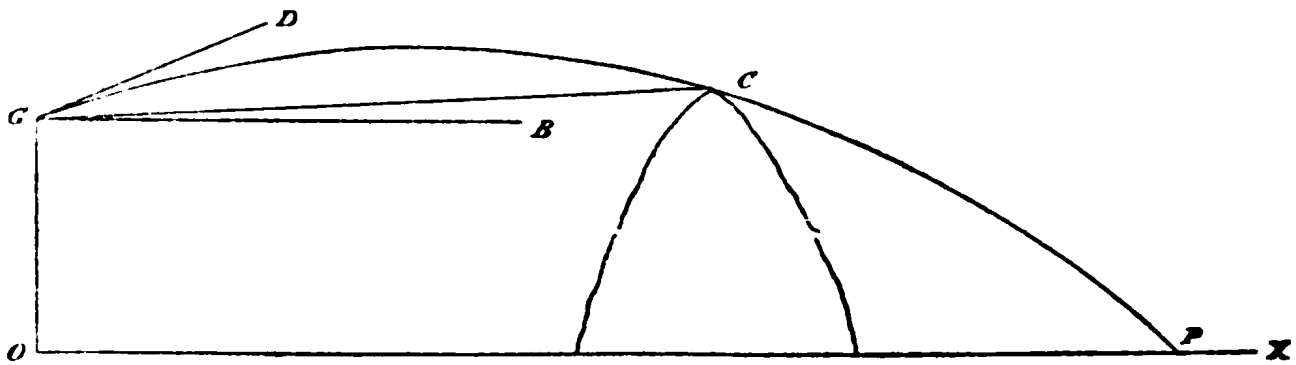

Fig. 36.

the angle of tangent elevation due to the range GC. Then BGD is the Q.E. for a trajectory that will graze the ridge at C.

In the corrected range table (*see* Sec. 2) the range corresponding to the Q.E. equal to BGD will be the range of the point P where the trajectory GCP arrives at the water. A target at a greater range than P can therefore be hit by the gun at G, provided a suitable means of fire direction is provided.

If the above process be performed for various points on the ridge of which the trainings are noted, data will be obtained from which the boundary of the dead water area can be indicated on a chart.

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10. *To determine the dead water for a P.F. or D.R.F.*

Level the instrument. Set the height drum to the height of the instrument above low water mark.

Lay the instrument on successive points on the water visible over the ridge intervening between it and the water area with regard to which information is required, and note the training and range for each point.

From these data the boundary of the dead water area can be indicated on a chart.

11. *Error in laying with rocking bar sights.*

1. In Fig. 37 suppose a gun at G, at a height GO (= h feet) laid with an error of n minutes above the water-line of the target T at a range of R yards.

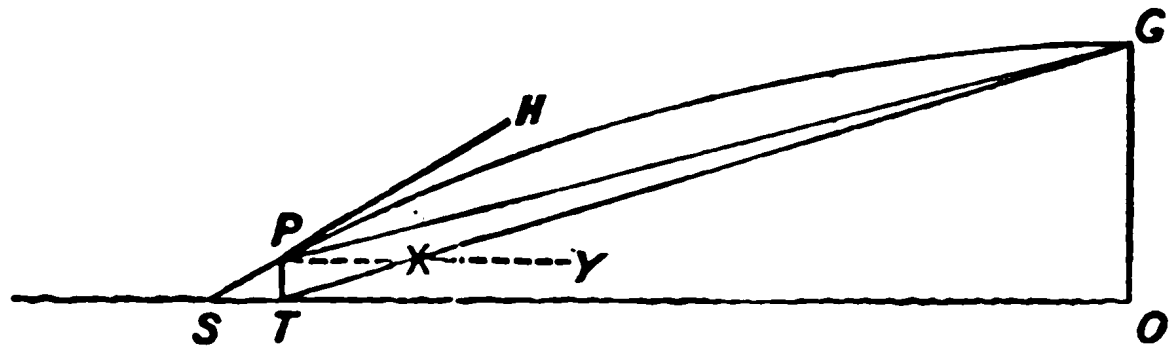

Fig. 37.

Draw GP = GT, making the angle PGT = n minutes, and PY parallel to TO, cutting GT in X.

Then the shot will range to P on the line of sight GP and will strike the water at a point S.

ST will be the error on the water.

$$\begin{aligned}\text{The angle PST} &= \text{HPX} = \text{HPG} + \text{GPX} \\ &= \text{HPG} + \text{GXY} - \text{PGX} \\ &= \beta + \alpha - n.\end{aligned}$$

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And $$ST = \frac{PT}{\tan(\beta+\alpha-n)}$$
$$= \frac{PT \times 1146}{\beta+\alpha-n},$$

when the angles are small.

But, since n is small, each of the angles GPT, GTP, which are equal, is nearly equal to a right angle, and $PT = \frac{nR}{1146}$ approximately.

$$\therefore \quad ST = \frac{nR \times 1146}{1146 \times (\beta+\alpha-n)} = \frac{nR}{\beta+\alpha-n}.$$

2. Similarly, if the layer had laid n minutes low, the error would be $\frac{nR}{\beta+\alpha+n}$.

12. *Error in laying with auto-sights.*

1. The layer may lay with an angular error above or below a target.

2. Suppose that, owing to any reason, the layer lays with an angular error of n minutes above or below the target T at a range R yards with a gun at G, h feet above M.S.L. (Fig. 38).

Make the angles TGS′, TGS″ = n minutes.

Since the lines of sight cut the water at S′ and S″, the shots will also strike the water at S′ and S″, and the errors on the water will be S′T, S″T.

The angle GS′T = angle GTO − angle S′GT

$$= \alpha - n.$$

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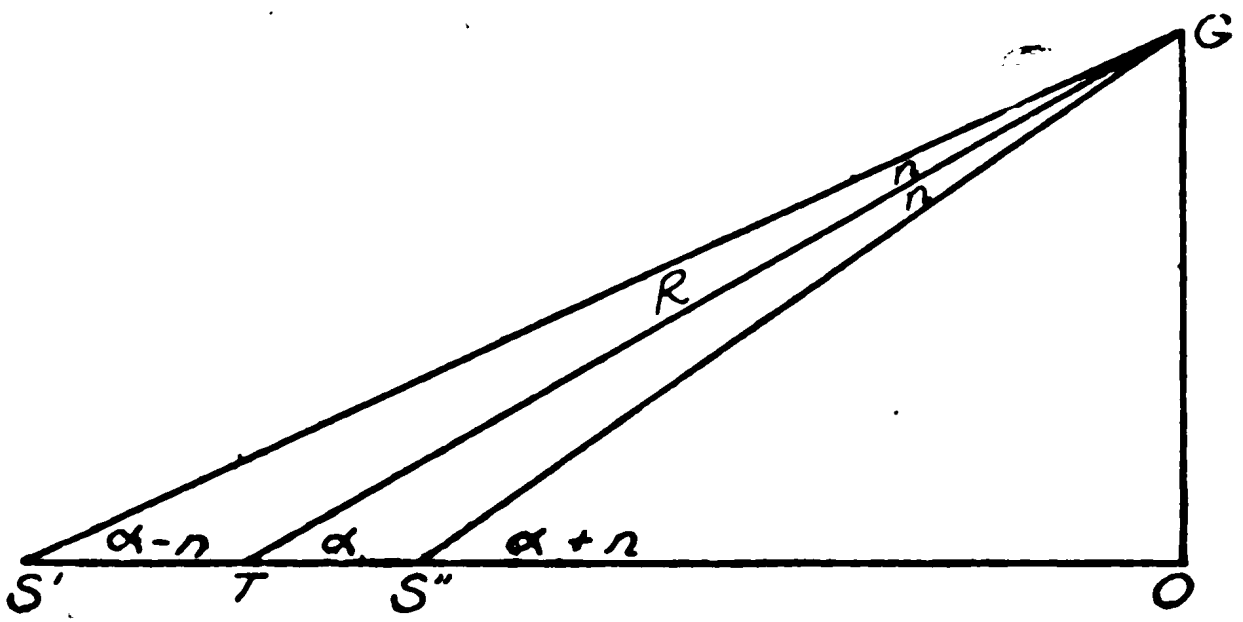

Fig. 38.

Since the sides of a triangle are proportional to the sines of the angles opposite to them,

$$\frac{S'T}{R} = \frac{\sin n}{\sin(\alpha - n)} = \frac{n}{\alpha - n}, \text{ since } \alpha \text{ and } n \text{ are small.}$$

$$\therefore \quad S'T = \frac{nR}{\alpha - n}.$$

Similarly $$S''T = \frac{nR}{\alpha + n}.$$

3. The general expression, therefore, for the effect of an error of n minutes in laying is

$$ST = \frac{nR}{\alpha}.$$

But $$\alpha = \frac{h \times 1146}{R}.$$

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$$\therefore \quad ST = \frac{nR^2}{1146 \times h} = \frac{100 \times 100 \times nr^2}{1146 \times h} \quad \text{or} \quad \frac{8{\cdot}7nr^2}{h},$$

where r is the number of hundreds of yards in the range.

4. The same formula applies when the sight bar is set in error to the wrong depression angle or when it is intentionally moved through an angle, for instance, when a correction is put on the error-of-day drum. It is also applicable to errors of laying with a depression range-finder or P.F.

5. Let the error of day drum be set so as to move the sight through m minutes, thus effecting a correction of A yards at a range of R_1 yards.

Let B yards be the correction at a range of R_2 yards effected by the same setting. Then

$$A = \frac{8{\cdot}7mr_1^2}{h}$$

and

$$B = \frac{8{\cdot}7mr_2^2}{h}.$$

$$\therefore \quad \frac{A}{B} = \frac{r_1^2}{r_2^2},$$

or

$$A = B \times \frac{r_1^2}{r_2^2}.$$

6. For example, suppose the setting of the error-of-day drum to be such as will effect a correction of 100 yards at 2,000, the correction obtained by this setting at 1,000 would be

$$100 \times \frac{100}{400} = 25 \text{ yards.}$$

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Conversely, to effect a correction of 25 yards at 1,000, the error-of-day drum must be set to give 100 yards at 2,000.

7. Clicking gear is designed so that one click effects a correction of 25 yards at 1,750 yards range. The value of a click at other ranges will be—

32·6 yards at 2,500, 18·4 yards at 1,500, 8·2 yards at 1,000, &c.

8. To compare the effect of an angular error when laying with auto-sights and rocking bar sights.

In Sec. 11, it was shown that the error when using tangent sights is

$$\frac{nR}{\beta + a \pm n}$$

$$\text{With auto-sights the error } ST = \frac{nR}{a \pm n}.$$

$$\frac{\text{Error with rocking bar sights}}{\text{Error with auto-sights}} = \frac{a \pm n}{\beta + a \pm n}.$$

Therefore the error with auto-sights is always greater than with rocking bar sights.

9. To illustrate the difference of effect produced by bad laying with automatic and rocking bar sights, the approximate errors, due to one minute error in laying with each method are compared below. The gun is a 6-inch B.L., mounted 100 feet above sea level. The target is stationary and the range is supposed to be accurately known. If the target were moving and a range-finder were used, errors due to faulty range-finding, and to possible errors in setting the sight, would, in the case of the rocking bar sight, also have to be considered.

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——	1,000 yards.	3,000 yards.	5,000 yards.
Error on the water with auto-sights	8·7	79	218
Error on the water with rocking bar sights	6·7	17	14

13. *Auto-sights.—Ratio of movement of gun to sight.*

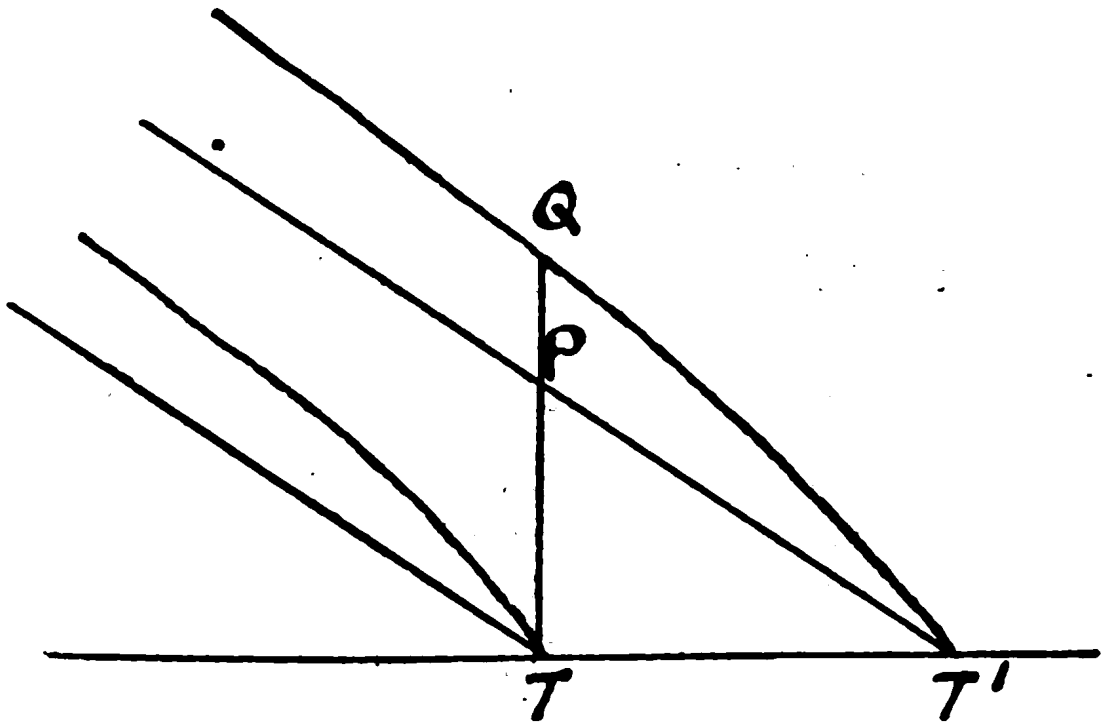

Fig. 39.

1. A knowledge of the ratio of movement of gun to sight at a certain range is frequently required.

Suppose that the line of sight and trajectory meet at T on the water, and that the gun has its elevation slightly altered to bring the trajectory to T'. (Fig. 39.)

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Then by the principle of the auto-sight, the gun and sight must be so connected that the latter also has simultaneously been directed on T′. Erect TPQ perpendicular to TT′ and let it cut the new line of sight PT′ at P, and the new trajectory QT′ at Q.

In order to get the trajectory from T to T′ it must have been raised from T to Q, and, assuming the rigidity of the trajectory, the gun must have been moved through whatever angle QT subtends at the range of the point T.

Similarly the sight must have been moved through whatever angle PT subtends at the same range.

The ratio of movement of gun to sight is therefore represented by QT/PT.

But $QT = TT' \tan(\beta+\alpha)$ and $PT = TT' \tan \alpha$.

$$\therefore \frac{QT}{PT} = \frac{\tan(\beta+\alpha)}{\tan \alpha} = \frac{\beta+\alpha}{\alpha},$$

where β and α are small.

The ratio of movement of gun to sight is therefore that of the angle of arrival to the angle of sight.

2. *Example.*—A 12-pr. Q.F. mounted 42 feet above sea-level is used for training layers, the target being at 1,500 yards. One of the layers out of five lays shows a mean error of 2·68 minutes in Q.E. What is his equivalent error in laying?

At 1,500 yards $\beta = 1° 39'$, $\alpha = 32'$.

Ratio of movement of gun to sight is $\frac{\beta+\alpha}{\alpha}$ or $\frac{131}{32}$, *i.e.* 4·1.

The mean error of the gun-layer is therefore $\frac{2·68}{4·1}$ or 65 minute.

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It is more convenient, however, to deal with the probable error than with the mean error, in questions affecting the shooting. The probable error is found by multiplying the mean error by ·845. The probable error of the above gun-layer is therefore ± ·55 minutes.

14. *Mechanical correction for tide.*

1. The movement of the line of sight that should be effected by the tide mechanism is found as follows :—

Suppose the line of sight and trajectory to intersect at T on the mean sea-level. (Fig. 40.)

If the tide rise *f* feet it is necessary that the line of sight

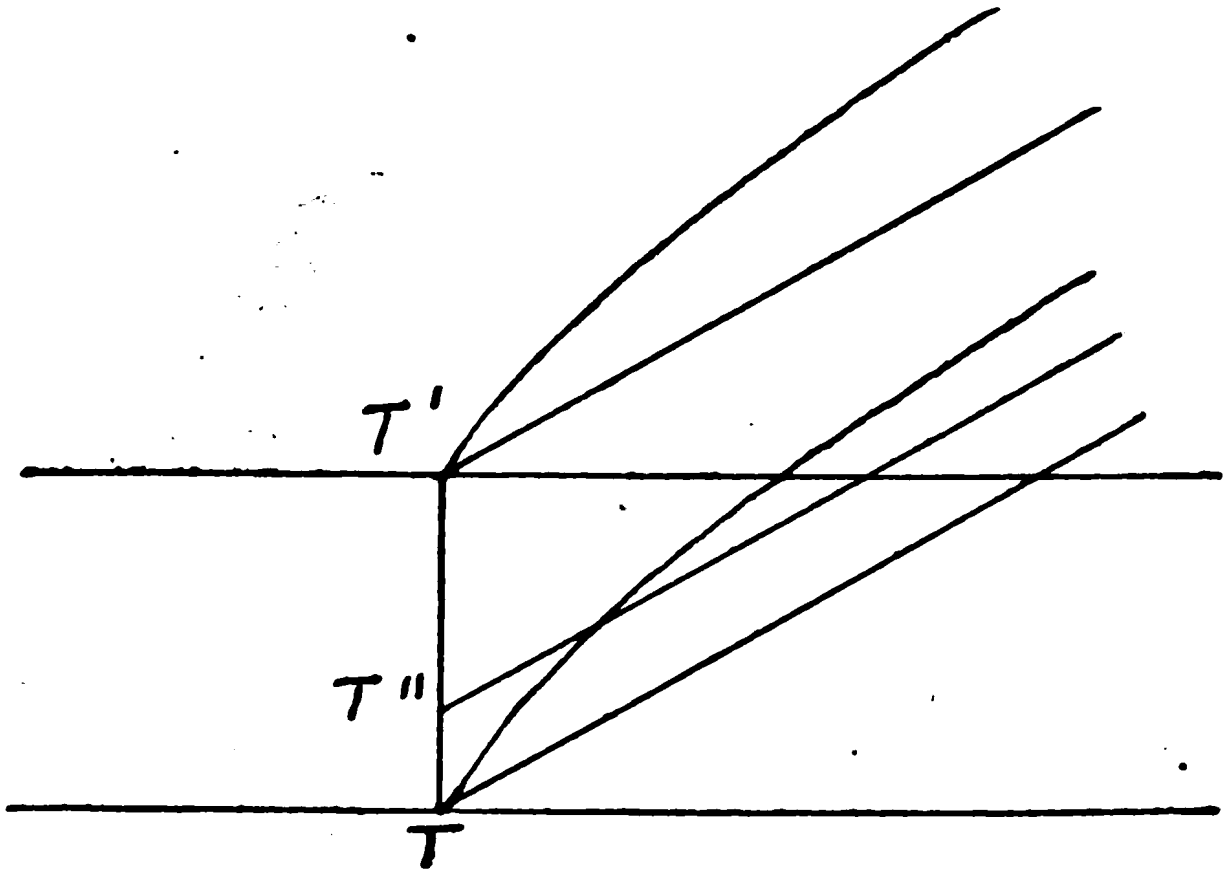

Fig. 40.

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and trajectory should be made to intersect at T′ on the new tide level.

The angle subtended at R yards by a height of f feet is $\frac{f \times 1146}{R}$ minutes.

The movement of the gun to raise the trajectory from T to T′ is therefore $\frac{f \times 1146}{R}$ minutes.

Since the ratio of movement of sight to gun is $\frac{a}{\beta + a}$, the line of sight will simultaneously be raised $\frac{a}{\beta + a} \times \frac{f \times 1146}{R}$ minutes, *i.e.*, to T″.

The independent movement of the line of sight to be given by the tide lever is that from T″ to T′.

$$\frac{f \times 1146}{R} - \frac{a}{\beta + a} \times \frac{f \times 1146}{R} = \frac{f \times 1146}{R}\left(1 - \frac{a}{\beta + a}\right)$$

$$= \frac{f \times 1146}{R} \times \frac{\beta}{\beta + a} \text{ minutes.}$$

2. To ascertain the movement actually given to the sight by the tide lever. Calculate for each range in the Woolwich table of angles, by the method given in the preceding section, the movement which the tide lever should give to the sight bar, taking f as the distance between high and low water marked on the tide scale (*e.g.* from 8 feet fall to 8 feet rise = 16 feet).

Lay the gun by clinometer at the proper Q.E. for each range in turn.

Without moving the gun, measure, by a clinometer on the bar testing sights, the movement given to the sight bar, at

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each range, when the tide lever is moved from greatest "rise" to greatest "fall."

At any particular range, half the difference between the angle calculated and the angle measured will be the error in minutes, at high *or* low water, due to the imperfection of the correctional arrangement.

It is instructive to draw on one piece of paper two curves, one showing the movement required, the other the movement given by the tide lever.

It will be found that the tide correction is true at only one or two ranges and that with low sites and large variations of tide, errors will be considerable at long ranges.

When the movement given by the tide lever is too great, the error in shooting will be minus for rise of tide and plus for fall and *vice versâ*.

3. The resulting error in range at high or low water will be

$$\frac{m\mathrm{R}}{\mathrm{D}} \text{ yards or } \frac{8{\cdot}7\ mr^2}{h},$$

where m is the error in minutes, R is the range in yards and D is the number of minutes in the depression angle. Errors for intermediate states of the tide will be in proportion. Errors in shooting to be expected at fighting ranges should be tabulated.

4. For guns used at night, the tide scale shall be so graduated as to give the proper correction at the Test Range (*see* Sec. **138** (2)).

15. *To graduate a tide lever scale.*

1. The sight should first be in adjustment in accordance with the Woolwich table of angles or the corrected table of angles (*see* Sec. **112**).

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2. Calculate for mean sea level at the Test Range (i) the Q.E., (ii) the depression angle of sight, making allowances in (i) for curvature, and (if desired) for variation from the range table M.V., and in (ii) for curvature, refraction and height of sight bar above the trunnions of the mounting.

Calculate the angle which each 2 feet difference of tide at the given range subtends at the gun.

3. Make out a table in the following form :—

12-pr. Q.F.

Range 1478. Trunnion height, 42·15 feet.

State of tide.		Angle subtended by rise and fall.	Q.E.	Depression angle.
	feet	mins.		
Rise	8	6·2	42·0	27·4
	6	4·65	40·45	28·95
	4	3·1	38·9	30·5
	2	1·55	37·35	32·05
	M.S.L.	0	35·8	33·6
Fall	2	1·55	34·25	35·15
	4	3·1	32·7	36·7
	6	4·65	31·15	38·25
	8	6·2	29·6	39·8

4. Set the tide lever at mean sea level, lay the gun at Q.E. for mean sea level and if the sight does not come to the proper depression angle make it correct with the eccentric bush or the error of the day drum.

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5. Lay the gun at each corrected Q.E. for different states of the tide in turn.

6. Bring the sight to the corresponding depression angle by moving the tide lever. (The last movement of the tide lever should always be in the direction of FALL.)

The position of the tide lever in each case will determine a graduation on the scale.

The graduations thus obtained will then be sub-divided.

16. *Error if tide lever is not set correctly.*

1. In Figs. 41 and 42 suppose the tide to have fallen, or risen, f feet, so that the target is f feet below or above mean sea level OX.

Suppose the tide lever neglected, and a gun, at height OG (= h feet) above mean sea level, laid on a target at T.

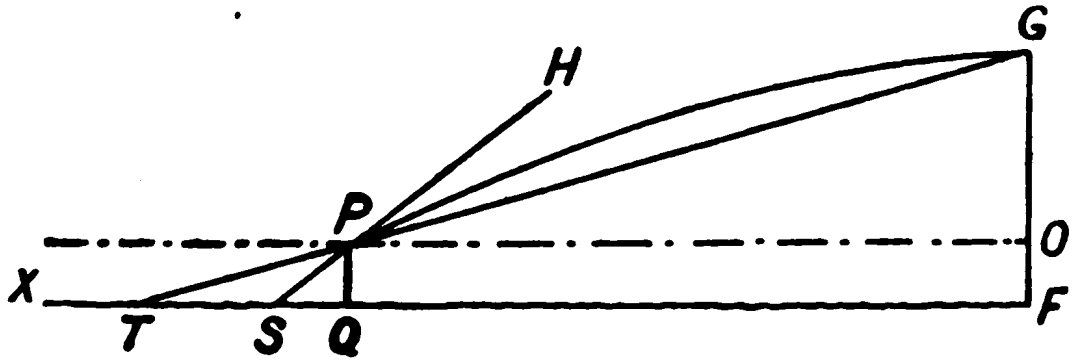

Fig. 41.

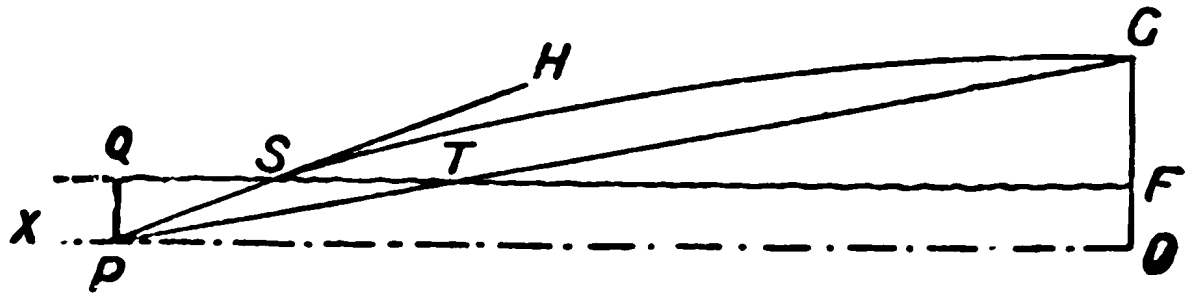

Fig. 42.

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By the principle of the sight, the trajectory will pass through P, the intersection of the line of sight and mean sea level, and the shot will strike the water at S.

ST is the error of the shot on the water.

$$\text{Now} \qquad ST = QT - QS = \frac{f \times 1146}{a} - \frac{f \times 1146}{\beta + a}$$

$$= \frac{f \times 1146 \times \beta}{a \times (\beta + a)},$$

$$\text{or, since } \frac{1146}{a} = \frac{R}{h}, \qquad ST = \frac{fR}{h} \times \frac{\beta}{\beta + a}.$$

In using the above formula it should be remembered that a is the angle of sight to the target, and therefore in the case of a fall of tide is due to a height of $(h+f)$ feet, whilst in the case of a rise of tide it is due to a height of $(h-f)$ feet.

To be strictly accurate, β should be determined for the range GP; it will be sufficiently accurate, however, to take it for the range of the target GT.

It will be noticed that as the height, and consequently a, increases, the error becomes less, but that, as the range increases, the error increases. Moreover, with increasing ranges, the fraction $\frac{\beta}{\beta + a}$ becomes more and more equal to 1 or "unity," showing that the error caused by wrongly estimating the height of the tide will increase rapidly with the range, especially with a low velocity gun.

17. *Error with auto-sights due to tilted pivot.*

1. To find the error in yards on the water if tilt is not corrected :—

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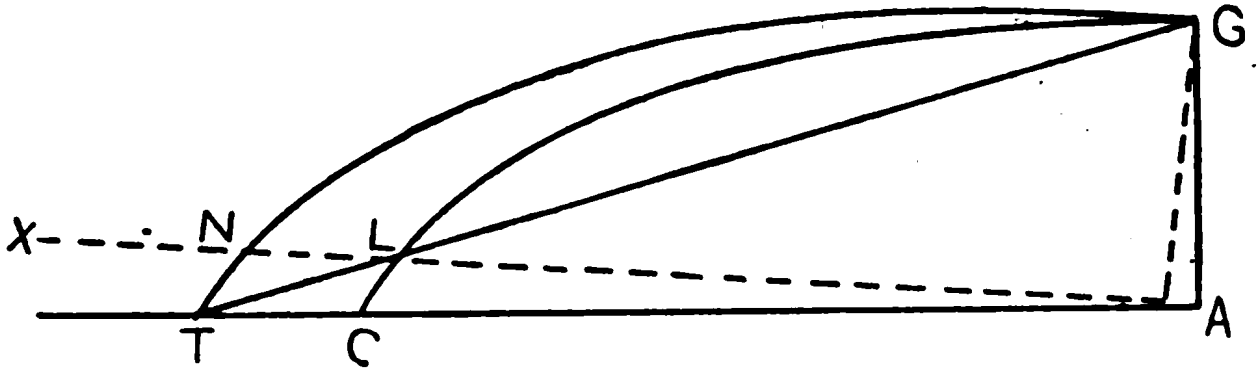

Fig. 43.—Tilt backward.

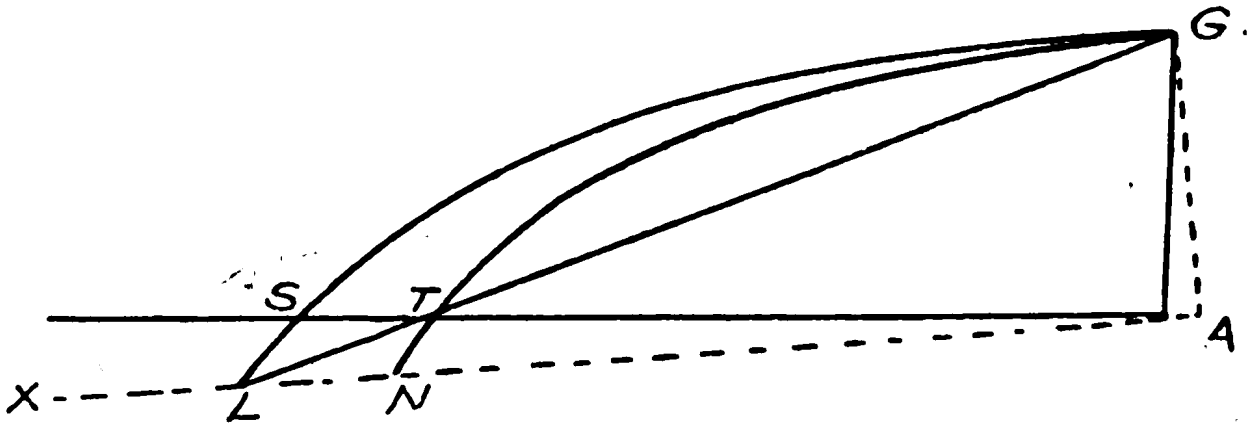

Fig. 44.—Tilt forward.

Suppose a gun at G, h feet high, is laid correctly with auto-sights on a target at T on the water level, and that the mounting be then tilted through n minutes. Both gun and sight will be tilted n minutes with it (Figs. 54 and 55).

To bring the trajectory back to the target the gun must be moved back through n minutes. The line of sight therefore should be moved back through $\frac{a}{\beta+a}$ n minutes.

But to bring back the sight line on to the target it is actually moved n minutes, or $n-\frac{a}{\beta+a}$ n minutes too much.

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The error on the tilted plane AX, perpendicular to the axis of the mounting, and h feet below the gun, is therefore that due to an alteration in the angle of sight of $\frac{\beta n}{\beta+a}$ minutes, which is equivalent to $\frac{8{\cdot}7\,nr^2}{h} \times \frac{\beta}{\beta+a}$ yards, where r is the number of hundreds of yards in the range.

Now if the line of sight through the target cuts the tilted plane at L, the trajectory will also pass through L and the shot will strike the water at S.

The error on the water will therefore be TS, but if n is small compared with $(\beta+a)$, as it generally would be, TS may be taken to be equal to NL, the error on the tilted plane.

$$\therefore \quad \text{TS} = \frac{8{\cdot}7\,nr^2}{h} \times \frac{\beta}{\beta+a} \text{ yards.}$$

2. Consideration of this formula will show that the error will be great from a low sited battery, and that it increases rapidly with the range. For large errors of tilt this formula is inexact; the error, with tilt backward, is less than that given by the formula, and, with tilt forward, greater.

3. In Sec. 4 it was shown that the amount of tilt at any training is equal to the maximum tilt multiplied by the cosine of the angle through which the gun has been traversed from the position of maximum tilt.

Hence, by causing the cam to shift in a suitable manner as the mounting revolves, the necessary correction may be applied automatically. This principle is applied to the more important guns by means of "correcting gear" by which errors up to 1^c are corrected. For greater errors, and with

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mountings not so fitted, the errors must be corrected by means of the levelling ring.

18. *Effective limit of auto-sights.*

1. With rocking bar sights, the result of a slight angular error in laying is to raise or lower the point of impact by some small amount, and, if the range has been accurately obtained by a range-finder, this is the only error that will occur.

If wrong quadrant elevation is put on a gun the error in yards on the water will be equal to the error in yards on the elevation indicator. With auto-sights, however, a small angular error in laying may, at long ranges, cause the projectile to fall considerably short of, or beyond, the target.

2. Bad shooting will therefore result if auto-sights are used at unsuitably long ranges. Battery commanders should, by a study of their guns, sights, and layers, be able to judge the limits beyond which, having regard to the target they are attacking, it is desirable to use some other method of laying.

To assist in determining these limits certain ranges should be worked out, in the manner about to be described, for each group or battery, and for various typical targets.

3. These ranges, though termed the effective limits of auto-sights for the particular targets, are only to be considered as guides, for determining the maximum range at which these sights should, as a rule, be used. If the sights are in good order and the layers well trained, auto-sights may occasionally be used outside these limits, but the worse the state of the sights and the training of the layers, the shorter will be the ranges within which the use of auto-sights is advantageous.

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4. In working out the effective limits of auto-sights it is assumed that faulty laying and defects in mechanism will produce a probable angular error in laying of ·4 minute. Compared with the result of this error, the inaccuracy of the gun itself is as a rule so small as to be negligible for present purposes, consequently 50 per cent. of the rounds will be covered by an angle of ·8 minute and will fall into a zone of water corresponding to a layer's error of this amount. The depth of this zone can be calculated by the formula in App. II, Sec. 12. If the depth of the zone, for a certain range and height of battery, is equal to the permissible error given by a certain target at the same range and for the same height of battery, then 50 per cent. of the rounds fired should be hits on that target. By convention this range is called the effective limit of auto-sights for that battery when engaging that particular target.

5. The effective limit of auto-sights may be conveniently arrived at in the following way. Work out the depth of the zone at three or four suitable ranges, plot the amounts on squared paper, and draw a curve through the plotted points. Then work out the permissible error corresponding to the target at each range, plot these amounts and draw another curve. The required range is the one at which the curves intersect. Curves may be drawn of the permissible errors due to each type of target, and their intersections with the first curve will give the effective limit of auto-sights for each type.

6. The method of calculating permissible errors is given in "Instructions for Practice Seawards." For long ranges the permissible errors for "overs" should alone be taken, but for shorter ranges, and when it is considered that ricochets may do damage, the sum of the permissible errors for "shorts" and "overs" may be used instead.

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7. The effective limit of auto-sight range for each group will be painted on the gun emplacement and inserted in the Fort Record Book.

19. *Probability of fire.*

Range tables contain "Accuracy Tables," these are based upon actual practice, and may be accepted as correct, provided that gun, ammunition and service are normal, and that the weather does not exercise a disturbing influence.

They give the length, breadth, or height of the zones which would contain 50 per cent. of the shots fired, provided that the mean point of impact were in the centre of the zone in each case.

Take, for instance, the 6-inch B.L., Mark VII, with full charge: at 5,000 yards the 50 per cent. length zone is given as 26 yards, and the breadth as 3·23 yards. A series of rounds might fall, as in Fig. 45, about a horizontal target T.

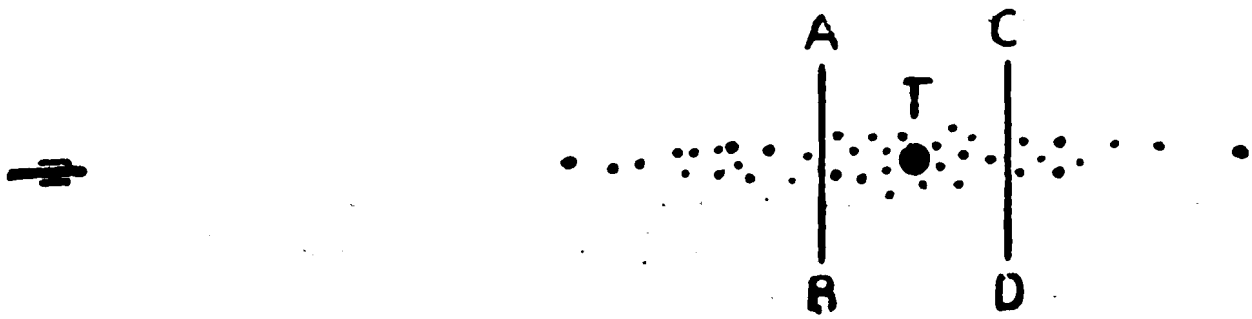

Fig. 45.

Of these 50 per cent. would be contained between the two lines AB, CD, 13 yards on each side, "short" or "over," of the centre of the group. Over 99 per cent. of the rounds should fall within two lines four times as far apart, viz., 104 yards apart, or 52 yards on each side of T.

Again, of the rounds that fall right or left of the centre of

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the series, 50 per cent. would be enclosed by the lines FE, HG, Fig. 46, 3·23 yards apart; and over 99 per cent. should

Fig. 46.

be contained by two lines four times that distance, or 12·92 yards, apart.

If now one pair of these lines be placed over the other, as in Fig. 47, evidently the rectangle enclosed by them will contain 50 per cent. of 50 per cent., that is, 25 per cent. of the total number of rounds.

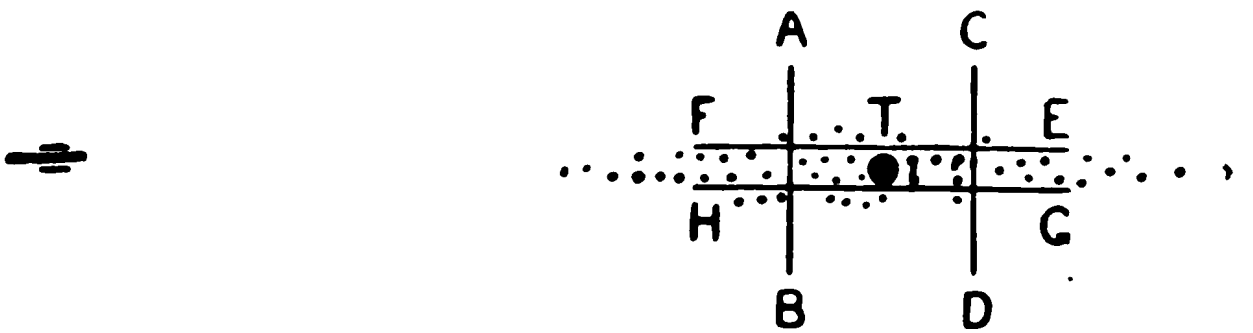

Fig. 47.

The distances, 104 yards and 12·92 yards, which are equal to four times the 50 per cent. zones, are called the "enveloping zones," on the assumption that a percentage of over 99 is practically equivalent to 100, and that therefore all rounds should be included.

The principle on which the 50 per cent. zones are arrived at is as follows:—

A series of rounds is fired at a certain range, and the mean

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point of impact of all the rounds is determined. If all the rounds were not fired at the same elevation, the fall of each shot must be corrected to where it would have been had the elevations been the same.* The distance of each round from the mean is then measured, and the sum of these distances, divided by the number of rounds, gives the mean deviation or mean error.

The mean error multiplied by ·845 gives what is known in the theory of probabilities as the probable error, which is an error of such magnitude, that it is an even chance whether any error will be greater than, or less than, it. It is also an even chance whether an error will be + or − the mean point of impact.

It follows that if a distance equal to the probable error be measured on each side of the mean point of impact, we shall get a zone containing half the + shots and half the − shots, or, altogether, 50 per cent. of the shots fired. In other words, the 50 per cent. zone may be obtained by multiplying the mean error by 1·69.

The 50 per cent. height zone is deduced from the 50 per cent. length zone, and depends on the angle of descent. A knowledge of the 50 per cent. height zone is of use when shooting at a vertical target.

If a gun be ranged at a target so that 3 shots fall beyond the target to 1 short (in other words, 75 per cent. falling over to 25 per cent. short), it is evident that the target may be considered as standing on the nearer edge of the 50 per cent. zone, and, as the whole enveloping zone is 4 times the 50 per cent. zone, the target is a distance from the near edge of the

* At practice at a moving target the fall of each shot is corrected to where it would have been had no range correction been given.

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enveloping zone equal to 1½ times the length of the 50 per cent. zone.

It is important to realize, at practice, the effect of these laws. We see in the above example, that (under favourable conditions), at 5,000 yards, a series of rounds might be expected to fall in a length of about 104 yards, and that, if the gun were ranged so that 75 per cent. of the shots fell over, to 25 per cent. short, shots falling 39 yards short, and 65 yards over, would not be outside normal limits of error, and that 50 per cent. of the shots fired should fall between the water-line of the target and a distance 26 yards over.

In this case the mean point of impact will be a certain height up the vertical target, depending on the angle of arrival.

It must be remembered that errors in range-finding, and in laying, must also be taken into account in estimating what is likely to be the total error in shooting.

Consideration of the above will show the necessity for making final range corrections on the result of the observation of groups of rounds.

If the size of any target be compared with the size of the 50 per cent. zone, we may, with the aid of a table of "Probability Factors," arrive at an estimate of the number of hits that may be expected on the target, when the mean point of impact is at the centre of the target.

The factor is got by dividing the total permissible error due to the size of the target by the corrected 50 per cent. length zone (*see* Sec. 2).

Obviously the factor for 50 per cent. is 1; a permissible error twice as great as the 50 per cent. zone would probably contain 83 per cent. of the shots fired, and so on. (*See* Table of Probability Factors.)

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TABLE OF PROBABILITY FACTORS.

Per cent.	Factor.	Per cent.	Factor.	Per cent.	Factor.	Per cent.	Factor.
1	0·02	26	0·49	51	1·02	76	1·74
2	0·04	27	0·51	52	1·04	77	1·78
3	0·06	28	0·53	53	1·07	78	1·82
4	0·07	29	0·55	54	1·09	79	1·86
5	0·09	30	0·57	55	1·12	80	1·90
6	0·11	31	0·59	56	1·14	81	1·94
7	0·13	32	0·61	57	1·17	82	1·98
8	0·15	33	0·63	58	1·19	83	2·03
9	0·17	34	0·65	59	1·22	84	2·08
10	0·18	35	0·67	60	1·25	85	2·13
11	0·20	36	0·70	61	1·27	86	2·18
12	0·22	37	0·72	62	1·30	87	2·24
13	0·24	38	0·74	63	1·33	88	2·30
14	0·26	39	0·76	64	1·36	89	2·37
15	0·28	40	0·78	65	1·39	90	2·44
16	0·30	41	0·80	66	1·42	91	2·52
17	0·32	42	0·82	67	1·45	92	2·60
18	0·34	43	0·84	68	1·48	93	2·69
19	0·36	44	0·86	69	1·51	94	2·78
20	0·38	45	0·89	70	1·54	95	2·91
21	0·40	46	0·91	71	1·57	96	3·04
22	0·41	47	0·93	72	1·60	97	3·22
23	0·43	48	0·95	73	1·64	98	3·45
24	0·45	49	0·98	74	1·67	99	3·82
25	0·47	50	1·00	75	1·71	100	4·00

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APPENDIX III.

Instructions for examination in range finding.

(A) Officers ; (B) Other ranks.

(A) *Officers.*

1. **Lieutenant-colonels are responsible for the efficiency of all range-finding instruments in their command, and will ensure that all captains and lieutenants, Royal Garrison Artillery, under their command are sufficiently instructed to pass a practical examination in the range-finder proper to their branch of the service, and are qualified to adjust the instruments and instruct in the same.**

2. The syllabus at the end of this appendix will be adhered to in such examinations.

3. Examinations in range finding will be held twice a year, at home and abroad. These examinations will be carried out at such times as the C.C.D. or the G.O.C. may direct.

4. They will be conducted by a Board consisting, when practicable, of a field officer of the Royal Artillery as President, and two other officers of the Royal Artillery as members. When possible, an instructor in gunnery will form one of the Board.

The C.C.D. or G.O.C. will deal with the proceedings of these Boards, as laid down in the King's Regulations for subjects (*a*) and (*b*) for promotion.

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5. Captains and lieutenants of the Special Reserve and Territorial Force Royal Garrison Artillery allotted to coast defence companies will also be required to pass a practical examination in the range-finder employed with the guns to which they are allotted in war, and qualify themselves to instruct in the same.

Commanders of coast defences will make the necessary arrangements for their instruction and examination.

(B) *Other ranks (regulars).*

6. An establishment of range takers will be maintained in each company suitable to the manning requirements of the guns allotted to the company, including a surplus to replace casualties.

7. Range finding is one of the qualifications for proficiency pay referred to in King's Regulations, and, to become qualified range takers or position finders, non-commissioned officers and gunners must qualify in the examination laid down in the syllabus at the end of this appendix.

8 All range-takers must be examined at least once a year before the annual practice. The Board of Examination will be the same as laid down in para. 4 of this appendix.

9. In each unit a list of qualified range takers will be recorded in a book kept for that purpose. A record of the tests applied and the results will be kept. This book will be produced at inspections.

10. The result of individual annual classifications will be entered on Army Form B 87.

11. As many range takers as possible will be exercised weekly under an officer, and records kept of these tests.

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12. Range takers' badges* are authorized to be drawn at the rate of 6 per company. They will be held by the qualified range takers who are placed highest on the list as the result of the annual classification.

13. Range takers who fail to qualify at the annual classification will be removed from the list of qualified range takers.

14. Qualified range takers who are found inefficient at practice or at the weekly test held under para. 11, or at other times, may be removed from the list of qualified range takers at the discretion of the lieutenant-colonel commanding.

Should any range takers so disqualified be in possession of a range taker's badge, the badge will be forfeited. The lieutenant-colonel commanding will decide as to their subsequent re-examination and restoration to the list.

Special Reserve and Territorial Royal Garrison Artillery.

(*Coast defence companies.*)

15. An establishment of range takers will be maintained in each company suitable to the manning requirements of the guns allotted to the company, including a surplus to replace casualties.

16. Soldiers of the Special Reserve and Territorial Force below the rank of serjeant are eligible to compete for appointment as range takers.

To qualify as range takers, non-commissioned officers and men will be required to pass the tests laid down for regulars, except that they will not be examined in mechanisms or methods of range finding not employed with the guns with which they drill or practise.

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* *See* "Clothing Regulations."

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17. All range takers must be examined and qualify at least once a year before the annual practice and within three months of its commencement. As soon as possible after the receipt of instructions for practice for the year, officers commanding units will submit to the C.C.D. a schemé showing guns in use, tests proposed to be applied, and dates of examination and periodical tests.

18. Periodical tests as laid down in these instructions will also be held when possible.

19. In each unit a list of qualified range takers will be recorded in a book kept for that purpose. The tests applied and a record of the results will be shown. This book will be produced at inspections.

20. Range takers may at any time be removed from the list of qualified range takers for incompetence at practice or failure at any test, at the discretion of the commanding officer.

21. Range takers' badges are authorized under the T.F. Regulations. They will be worn by N.C.Os. and men as long as they remain qualified range takers.

22. At the annual examination which will be carried out under regimental arrangements a gunnery instructor of the Regular Forces should, if possible, be present.

Syllabus for examination in depression range finding.

In order to qualify, 75 per cent. of the total marks must be obtained, with not less than 60 per cent. in any test.

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Tests.

I.—*Setting up the instrument.* It must be well levelled, and the time taken must not exceed 5 minutes. **[15 marks.]**

II.—(*a*) *Finding height* of instrument using a *datum point* at a known range.

(*b*) *Calculating height* of instrument from height recorded at D.R.F. pedestal, and state of tide. **[15 marks.]**

III.—*Orienting instrument.* **[5 marks.]**

IV.—*Finding the range to a stationary target.*

The range will be taken 5 times, and each reading recorded as accurately as possible. Between the readings the instrument will be run off the target, sometimes to a greater and sometimes to a lesser range.

The Board will work out the mean of the readings, and also the mean variation from that mean. The mean reading and quickness of range-taking must be considered satisfactory by the Board, and the mean variation must not exceed $2r^2/h$ yards, where r = the number of hundred yards in the range, and h = the height in feet. **[15 marks.]**

V.—*Following a target.*

The candidate will follow, with the D.R.F., a target at a suitable range and moving, if possible, faster than 10 knots. He will be ordered to stand aside from time to time, and, as soon as he is clear of the instrument, a member of the Board will satisfy himself that the instrument is being kept on the true water-line of the target.

When convenient an independent instrument may be used to assist in this test. **[15 marks.]**

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VI.—*Duties* of observer, drum reader, and dial number. **[10 marks.]**

VII.—*Illuminating cross wires* for night work. Use of electric lamp, leads, switch, and Leclanché cells. **[5 marks.]**

VIII.—*Testing an instrument* for adjustment, and explaining principal adjustments. Actual adjustment of instructional instrument if available. **[15 marks.]**

IX.—*General care* of the instrument. **[5 marks.]**

Syllabus for examination in position finding.

Before attempting to qualify in position finding, candidates must have qualified as D.R.F. specialists.

In order to qualify, 75 per cent. of the total marks must be obtained, with not less than 60 per cent. in any test.

Tests.

	Marks.	Total marks.
I. Batteries and cells—		
(*a*) Composition and use of the various batteries	5	
(*b*) Testing Leclanché cells. Faults and their remedies	10	
		15
II. Telephone. Use of and simple tests for the telephone	—	10
III. Mechanical tests of Position Finder ...	—	25
IV. Signals. Ability to read without reference	—	10
V. Electrical connections—		
(*a*) Tracing and connecting up the various circuits	25	
(*b*) Faults and their remedies	10	
		35

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	Marks.	Total marks.
VI. Drill as Observer—		
(*a*) Preparation for action	10	
(*b*) Datuming and focussing	10	
(*c*) Putting corrections on the instrument	10	
(*d*) Finding the range to stationary target five times on the principle of D.R.F., Test IV	25	
(*e*) Following a target	15	
		70
VII. Duties of Chartman	—	5
VIII. Drill as Dial Reader—		
(*a*) Preparation for action	5	
(*b*) Applying corrections to movable faces	5	
(*c*) Reading dials	5	
		15
IX. Care and preservation of instrument and chart	—	15
Grand total... ...	—	200
X. In stations where Horizontal Position Finders are installed, the following tests will be taken in addition to those above—		
H.P.F. circuits	10	
Use of telephone attachment and rough tests	5	
Duties of Transmitter	10	
Duties of Assistant Observer	10	
Duties of Observer	10	
Duties of Chartman	5	
		50
Grand total... ...	—	250

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Form II.

For recording results of Examination in Range Finding or Position Finding.

Place..... Date.....

No. of Instrument..... Mark and Letter ..... Height over sea.....ft.

Datum Point, Range..... Value of $\frac{2r^2}{h}$.....

Description of Datum Point.....
State of weather, wind, sea, light .....
Description and speed of moving target .....
How was following of moving target checked? .....

Marks Gained.

Name of Candidate.	Test I.	Test II.	Test III.	Test IV.	Test V.	Test VI.	Test VII.	Test VIII.	Test IX.	Test X.	Total.	Mean variation in Test IV, D.R.F., or VI (*d*) P.F.	Remarks by Board.

Signature of President of Board.

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APPENDIX IV.

Instructions for examination in gun laying.

Regulars.

1. An establishment of gun layers will be maintained in each company suitable to the manning requirements of the guns allotted to the company, including a surplus to replace casualties.

2. Gun laying is one of the qualifications for proficiency pay referred to in King's Regulations, and to be qualified gun layers, non-commissioned officers and gunners must qualify in the examination laid down in the syllabus at the end of this appendix.

All gun layers must be examined at least once a year before the annual practice. The Board of Examination will be the same as laid down in Appendix III, para. 4.

3. In each unit a list of qualified layers will be recorded in a book kept for that purpose. The tests applied and a record of results will be kept. This book will be produced at inspections.

4. The result of individual annual classifications will be entered on A.F. B 87.

5. As many layers as possible will be exercised weekly under an officer, and records kept of these tests.

6. Gun layers' badges* are authorized to be drawn by a company up to 15 per cent. of its peace establishment.

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* *See* "Clothing Regulations."

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They will be held by the qualified layers who are placed highest on the list as the result of the annual classification.

7. Gun layers who fail to qualify at the annual classification will be removed from the list of qualified gun layers.

8. Qualified gun layers who are found inefficient at practice, or at the weekly tests held under para. 5, or at other times, may be removed from the list of qualified layers at the discretion of the lieutenant-colonel commanding.

Should any gun layer so disqualified be in possession of a gun layer's badge, the badge will be forfeited.

The lieutenant-colonel commanding will decide as to their subsequent re-examination and restoration to the list.

Special Reserve and Territorial Royal Garrison Artillery.

(*Coast defence companies.*)

9. An establishment of gun layers will be maintained in each company suitable to the manning requirements of the guns allotted to the company, including a surplus to replace casualties.

10. Soldiers of the Special Reserve and Territorial Force, below the rank of serjeant, are eligible to compete for appointment as layers. To qualify as layers, non-commissioned officers and gunners will be required to pass the tests laid down for regulars, except that they are not to be examined in mechanisms or methods of laying and firing not employed with the guns with which they drill or practice.

11. All layers must be examined and qualify at least once a year before the annual practice and within three months of its commencement. As soon as possible after the receipt of instructions for practice for the year, officers commanding units will submit to the Coast Defence Commander a scheme

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showing guns in use, tests proposed to be applied, and dates of examination and periodical tests.

12. Periodical tests, as laid down in these instructions, will also be held whenever possible.

13. In each regiment a list of qualified layers will be recorded in a book kept for that purpose. The tests applied, and a record of the results will be shown. This book will be produced at inspections.

14. Layers may, at any time, be removed from the list of qualified layers for incompetence at practice, or failure at any intermediate test, at the discretion of the commanding officer.

15. Gun layers' badges are authorized under the T.F. Regulations. They will be worn by N.C.Os. and men as long as they remain qualified layers.

16. At the annual examination, which will be carried out under regimental arrangements, a gunnery instructor of the Regular Forces should, if possible, be present.

Syllabus for examination in gun laying.

In order to qualify 75 per cent. of the total marks must be obtained, with not less than 60 per cent. in any test.

Tests.

I.—*General knowledge and reliability.*

(*a*) Watkin clinometer—using, setting, reading

(*b*) Tangent or rocking bar sights—rapid and accurate setting of five elevations and deflections.

(*c*) Auto-sights—names and uses of various parts, testing the adjustment, and rapid and accurate setting of the error-of-day drum with 6-inch and 9·2-inch guns.

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(*d*) Traversing arc—use in laying and testing adjustment of pointer.
(*e*) Method of preparing electric dials for action, with P.F. or mechanical dials. **[10 marks.]**

II.—*Means of firing.*

(*a*) Removing, stripping, adjusting, and replacing locks and strikers, gauging protrusion.
(*b*) Firing circuits—connecting up and testing **[10 marks.]**

III.—*Laying for line. Telescopic sights.*

Two sets of sights will be used. The layer using one set will keep the gun layed for line on a moving target for one minute. The officer, by means of the other set of sights, will check the laying five times during this minute.

When checked, the line must be within 2½ minutes of the correct line, otherwise no marks will be scored for that occasion. **[10 marks.]**

IV.—*Auto-sights.*

(*a*) *Target.*—A well-defined stationary object in the water will be chosen; if none is available, an anchored target will be used. The range must be long enough for the ratio of movement of gun to sight to be more than 3 to 1, but reduced charge or aiming rifle cams may be used.
(*b*) *Laying.*—Telescopes should be used.

Each competitor will lay five times on the water-line of the target. Before each lay the gun will be traversed, so that the target is clear of the field of the telescope, and the

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gun will be elevated above the target before three lays, and depressed, before the other two, two or more turns of the handle being given in each case in addition to any turns required to absorb backlash in elevating gear.

The officer will order "*Lay.*" The competitor will then lay, call "*Fired,*" and step clear. The interval between "*Lay*" and "*Fired*" will be measured each time. During two of these intervals deflection will be changed by the layer, according to directions given by the officer before the order "*Lay.*"

(*c*) *Checking the laying.*—The officer will note if each lay is within $2\frac{1}{2}$ minutes for line.

A clinometer will be kept on the gun, and the Q.E., after each lay, will be carefully read and noted, but the gun-layer should not be told the result of any lay until he has finished. The sum of these lays, divided by the number of them, is the mean lay. The difference between each lay and the mean will then be taken, and the sum of these differences, irrespective of sign, divided by the number of lays, is the *layer's mean error along the gun.*

With every auto-sight a "Table of Angles" is issued, showing corresponding angles of Q.E. and sight. If two angles of Q.E. are chosen, one on each side of the Q.E.'s of the gun during the test, and the difference between them is taken, and also the difference between the corresponding angles of sight, then the ratio which the difference in Q.E. bears to the difference in angle of sight may be taken as the ratio of movement at the range used, or the ratio of movement may be ascertained, as described in App. II, Sec. 13.

If the layer's mean error be divided by the figure expressing this ratio, the result is the *layer's mean error along the sight.*

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(*d*) *Qualifying.*—To qualify, every lay must be within 2½ minutes of the proper line. The layer's mean error along the sight must be less than ·4 minute. The total of the times taken for five lays must not exceed 1 minute for 6-inch guns and upward, nor 45 seconds for guns of less calibre.

(*e*) *Record.*—The lays should be plotted on a diagram; each layer's proficiency can then be seen. **[30 marks.]**

V.—*Laying for line, by traversing arc.*

Trainings will be called out by the setter for line to represent the uniform movement of a target.

The layer will keep the gun layed by means of the traversing arc for one minute, moving the gun evenly between the graduations on the arc at approximately the rate of change of training.

The officer will check the laying five times during this minute.

When checked, the laying must be within ⅛° of the correct training. **[10 marks.]**

VI.—*Laying for elevation. Elevation indicator.*

Ranges will be called by the setter for range, mechanical and electrical dials being used, the ranges being those at which the Q.E. corresponds to a range of 7,000 yards, or thereabouts, for medium guns with full charges, and 9,000 yards, or thereabouts, for heavy guns with full charges. The gun to be balanced as for firing.

A layer will be stationed at the pistol grip to call "Fired," or to ring a bell inserted in the circuit, on the word "On" from the layer under test. The officer will order "Pass ranges."

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After five or six ranges have been called, the officer will order, "Gun fire, Commence firing."

A number stationed at the breech will then give "Ready," and the layer under test will call "On" when laid.

"Ready" will subsequently be called at intervals corresponding to the rate of fire of the gun used.

The above will be carried out five times with a shortening range and five times with a lengthening range. With the shortening range, the total of the times from "Ready" to "On" must not exceed 4 seconds, and with the lengthening range must not exceed 6 seconds.

The gun must be depressed each time through at least 300 yards, and must be accurately laid to within 10 yards, the layer allowing for the rate of change of range.

The rate of change of range should not be slower than 50 yards in 20 seconds.

If the layer elevates before the layer for line fires or calls "Fired," no marks will be scored for that round. **[20 marks.]**

VII.—*Dial reading.*

The officer will test the layer's accuracy in reading range and training dials, in applying corrections to both and deflection to the training arc pointer, in preparing for Case III and in applying convergence; also in reading the range indicator.

Great attention is to be paid to the clearness in calling ranges and trainings. **[10 marks.]**

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APPENDIX V.

INSTRUCTIONS FOR THE EXAMINATION IN SKILL-AT-ARMS FOR GUNNERY BADGES.

1. Regulars.

1. A competitive examination for skill-at-arms badges by companies R.G.A. will be carried out annually by a Board of Officers appointed by the C.C.D. or G.O.C. on application by the Lieutenant-Colonel or other Officer Commanding.

2. This competition will be open to N.C.Os. and men (District Establishment excepted) who are selected as smart and good artillerymen by the company commander. They will be examined as follows :—

(*a*) A written examination on papers prepared by a Gunnery Instructor, or other officer appointed by the C.C.D. or G.O.C. All the examinations in the same command will be held on a given day, which will be published in Orders.

(*b*) A practical examination on drill and knowledge of artillery material at the station.

3. The examination may be carried out simultaneously with that for Proficiency Pay, if it is so desired.

4. The badges will be awarded to those best qualified, as recommended by the Board, to the number of—

One 1st class and one 2nd class badge per company for serjeants.

One 1st, one 2nd, and one 3rd class badge per company for N.C.Os. (under the rank of serjeant) and men.

To qualify for a badge a competitor must obtain ·5 of the maximum.

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5. A list of the individual winners of badges will be forwarded by the President of the Board to the C.C.D. or G.O.C., and, if approved, will be published in Command Orders. The badges will be at once taken into wear, and will be worn until the publication of the list of the next year's winners.

6. The examination papers, and results of the same, will be retained in the office of the Lieutenant-Colonel until after the date of the next inspection by the C.C.D. or G.O.C.

2. R.G.A. Special Reserve and Territorial R.G.A. (Coast Defence Companies).

1. A competition for skill-at-arms badges by coast artillery companies of each corps will be carried out annually, at the option of the Commanding Officer, under the following conditions :—

i. The theoretical examination for individual badges will be either written or *vivâ voce* under the direction of the Commanding Officer, who will award marks and classify winners. Written examinations will be carried out when arrangements can be made for the attendance of all applicants on the same day. When this is not feasible, proposals for a *vivâ voce* examination should be submitted for the approval of the C.R.A. in the district.

ii. Badges will be awarded to the successful competitors in the theoretical examination as follows. They will be worn until the next award.

For the N.C.O. (below the rank of serjeant) or gunner in each company who is first in the competitive examination prescribed above.

For the second N.C.O. or gunner in each company.

For the third N.C.O. or gunner in each company.

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APPENDIX VI.

Instructions regarding Telephone Messages.

In order to maintain an efficient telephone service in a coast fortress regular telephone drill is required in the same way that regular gun drill is required.

To standardize the system of sending telephone messages throughout the R.G.A. the following instructions and specimen messages have been drawn up.

A copy of these instructions and specimen messages, amplified if necessary to suit local conditions, will be kept in each telephone cell.

A handbook of the local telephone system should be drawn up in each fortress, and a copy kept in each telephone cell.

Instructions for operators.

1. Operators are not to leave their telephones during drill, practice, action, or on mobilization, unless properly relieved ; orderlies are detailed to deliver messages.

2. The operator will see that all binding screws are clean and tight, that the instrument is properly connected up, and that he has sufficient forms and carbon paper. He will then test his instrument by ringing up and speaking to the distant station. *With* 5 *and* 10 *line concentrators he must do this with every station.* If any error is found the tests as laid down in this book are to be applied.

3. Operators may test, but are not allowed to correct faults, unless qualified to do so, but all faults must be reported to the officer in charge of signals.

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4. Operators are responsible that their watches or clocks agree with "official time;" the latter can be obtained from the posts of section commanders.

Classification of messages.

5. Messages are divided into Class 1 and Class 2.

6. Class 1, or executive messages, are messages which convey important orders or information. Thus during practice or action messages between fortress commander, section commander, fire commander, and battery commander will be Class 1 messages.

7. Class 2, or administrative messages, are messages referring to equipment, rations, ammunition, &c., and will not be forwarded until practice or action is over.

8. Class 1 messages take precedence over Class 2 messages.

9. Messages may be sent as :—

(*a*) Written messages, which will usually be employed.
(*b*) Verbal messages, which will be used when great rapidity in delivery is required.

10. Priority for any particular written message can be secured by inserting "Immediate" as the first word in the text of the message; such messages will be given precedence of all other written messages by operators in exchanges or other posts. Messages are only to be so marked by officers of and above the position of fire commanders.

11. Verbal messages must take precedence of all others, and if a written message is being sent at the time a verbal message is required to be despatched, the transmission of the written message will be delayed until the verbal message has gone through.

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Preparation of written messages for despatch.

12. Messages for despatch will be written on A.F. C 2121 (white).

The address should always be written in full.

The sender's number should be inserted.

If the message is in reply to, or has reference to a message from the addressee, the number of that message will be quoted in the space provided for that purpose.

The text of the message will follow.

The message will end with the full title of the sender, *e.g.*, "Section Commander, West," or "Fire Commander Needles," followed by the time at which it was written. The place of despatch need only be sent if it is not the sender's war post.

The message will be signed by the sender in the right hand bottom corner. This signature is not to be transmitted, but is the authority for transmission.

If a message is to be transmitted to more than one address it facilitates transmission if separate copies for each addressee are handed in at the telephone office; in no case should more than three addressees appear at the top of the form.

13. The operator must always enter the time he completes sending a message, and sign the same on A.F. C 2121 in the space provided at the top of the form. He will also give each message a consecutive number and fill in the same in the space provided for it in the right hand top corner of the form.

At posts containing more than one instrument, each instrument should be given a distinguishing letter, which should be entered on all messages, with the number of the message.

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Sending messages.

14. A short ring will be used to ring up. Place the telephone to the ear, if an answer is not received, ring up again, but operators at B.C.'s telephones that are connected to F.Cs. or concentrators must not be in too great a hurry, as the distant station may be engaged with another B.C.'s station ; if, however, the message is urgent, he should call attention by several short successive rings.

For example, B.C. Redan has a message for F.C. Blackrock ; B.C. Redan rings up and places receiver to his ear. F.C. Blackrock says "F.C. Blackrock." B.C. Redan sends "Write down" or "Verbal message" as the case may be, afterwards sending the text of the message.

15. The body of the message will be sent two or three words at a time, the receiving operator repeating them as he writes them down, the repetition of the last word being a signal to the sender to go on.

At the end of a message the sender will say "End repeat," when the receiving operator will repeat the whole of the message.

16. Operators should speak slowly, distinctly, and avoid shouting ; sentences must be broken up, and any difficult words spelt.

Figures will be sent as "Three, six, five," not as "Three hundred and sixty-five" ; it is easy then to correct a figure which cannot be understood ; thus, the figure six is not easy to send through a telephone, but it can be made plain by saying "Twice three are six."

Receiving messages.

17. Messages received should be written on A.F. C 2123 (pink), in duplicate, and numbered consecutively, the

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original or top copy being retained by the telephone operator, and the duplicate or bottom copy delivered to the addressee.

The receiver must always enter the time he completes receiving a message in the space provided for that purpose, and sign A.F. C 2123 in the space at the top of the form.

Verbal messages.

18. Records of all verbal messages are to be kept on the forms supplied for the purpose.

19. One N.C.O. or man at each station will be made responsible for the recording of all verbal messages.

20. On the arrival of the warning "Verbal Message" in the receiving office the orderly will stand near the telephone and learn the message by listening to the receiving operator repeating it; as soon as the message is passed as correct by the sender the orderly will double to the addressee and repeat the message.

General messages.

21. With F.C.'s 5-line concentrators, that are connected with two or more B.Cs., it is sometimes necessary to send a message that is common to all B.Cs.; this is called a general message, and the procedure is as follows:—

F.C. rings up the first station, and, having received an answer, says "General message coming." He repeats this procedure with each of the other stations, thus:—

Answer "B.C. Redan."
F.C. replies "General message."
B.C. Redan then waits with receiver to his ear.

F.C. then goes to next B.C. and repeats the above procedure; when he is sure of their attention he will send

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"Write down" or "Verbal message" as the case may be, and sends the message.

While the message is being sent no B.C.'s telephonist is to speak; if he has missed part of the message, he will leave a blank space for it on the form.

When the message has been sent, the F.C.'s operator will say "End; B.C. Redan repeat" (other B.C. telephonists, by listening to B.C. Redan repeating, will be able to correct their messages); when B.C. Redan has repeated correctly F.C. gives "Correct," and asks next B.C. to repeat, and so on until all messages have been checked.

22. In the case of general messages, F.C.'s telephonists are cautioned that only the slowest and plainest of speech will produce good results, and each two or three words will be sent twice, allowing time for them to be written, before sending the next two or three.

Filing messages.

23. Messages on A.F. C 2121 (messages sent) and A.F. C 2123 (messages received) are to be filed separately and in numerical sequence.

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"A" Form. Army Form C 2121.

MESSAGES AND SIGNALS. No. of Message .....

Prefix..... Code.....m.	Words / Charge	This message is on a/c of:	Recd. at .....m.
Office of Origin and Service Instructions.	Sent	.....Service.	Date .....
.....	At .....m.	.....	From.....
.....	To	(Signature of "Franking Officer.")	By .....
.....	By		

TO	Section	Commander	West	

Sender's Number. 121	Day of Month.	In reply to Number 36	AAA

Hostile	cruiser	seven	miles	south
Star	Point	steaming	west	escorting
three	transports			

As written or dictated by F.C. SPY HILL.

Spaces to be left blank as in this specimen.

From	Fire	Commander	Spy Hill	
Place		Spy	Hill	
Time*	4.30 p.m.			

The above may be forwarded as now corrected.

..... Censor.

(Z)
S. PALISER, Major.
Signature of Addressor or person authorised to telegraph in his name.

* Time message was written out by F.C. Spy Hill.

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"A" Form. Army Form C 2121.

MESSAGES AND SIGNALS. No. of Message, B. 13.

Prefix..... Code.....m.	Words	Charge	This message is on a/c of:	Recd. at .....m.
Office of Origin and Service Instructions.			.....Service.	Date* 17.3.13
.....	Sent At† 4.35 p.m.		.....	From .....
.....	To		(Signature of "Franking Officer.")	By .....
.....	By† C.S.			

TO	Section	Commander	West	

Sender's Number.	Day of Month.	In reply to Number.	AAA
121		36	

Hostile	cruiser	seven	miles	south
Star	Point	steaming	west	escorting
three	transports			

As completed by SENDING OPERATOR.

Spaces to be left blank as in this specimen.

From	Fire	Commander		
Place	Spy Hill			
Time	4.30 p.m.			

The above may be forwarded as now corrected.	(Z) S. PALISER, Major.
..... Censor.	Signature of Addressor or person authorised to telegraph in his name.

* Operator's number and date.

† Time operator completes sending of message, and initials of operator.

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'C" Form (Original). Army Form C 2123.

MESSAGES AND SIGNALS. No. of Message, 17.

Prefix..... Code..... Words.....	Received	Sent, or sent out	Office Stamp.
£ s. d. Charges to collect	From ..... By L.P.	At ..... m. To ..... By	17.3.13
Service Instructions.			

Handed in at the.....Office, at.....m. Received here at 4.35 p.m.

TO { Section Commander West.

Sender's Number. 121	Day of Month.	In reply to Number. 36	AAA
Hostile	cruiser	seven	miles
south	Star	Point	steaming
west	escorting	three	transports

Copy retained by RECEIVING OPERATOR.

Spaces to be left blank as in this specimen.

From	Fire Commander.
Place	Spy Hill.
Time	4.30 p.m.

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"C" Form (Duplicate). Army Form C 2123.

MESSAGES AND SIGNALS. No. of Message, 17.

L.P.	Charges to pay. £ s. d.	Office Stamp. 17.3.13
Service Instructions.		

Handed in at the.....Office, at.....m. Received here at 4.35 p.m.

TO { Section Commander West.

Sender's Number. 121	Day of Month.	In reply to Number. 36	AAA
Hostile	cruiser	seven	miles
south	Star	Point	steaming
west	escorting	three	transports

Message as handed to ADDRESSEE.

Spaces to be left blank as in this specimen.

From	Fire Commander.
Place	Spy Hill.
Time	4.30 p.m.

(B 11429) S

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Verbal Messages Sent.

From .....

Time sent.	To whom sent.	Gist of Message.	Name of Operator.

Verbal Messages Received.

By .....

Time received.	From whom received.	Gist of Message.	Name of Operator.

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NOTE.—No reference to drill is made in this index. Headings of sections dealing with drill will be found in the contents.

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